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GIVING THE PROJECT METHOD A TRIAL.[1]

BY GEORGE D. VON HOFE, JR.,

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"Probably the greatest and commonest mistake that we all make is to forget that learning is a necessary incident of dealing with real situations. We even go so far as to assume that the mind is naturally averse to learning--which is like assuming that the digestive organs are averse to food and have either to be coaxed or bullied into having anything to do with it. Existing methods of instruction give plenty of evidence in support of a belief that minds are opposed to learning—to their own exercise. We fail to see that such aversion is in reality a condemnation of our methods; a sign that we are presenting material for which the mind in its existing state of growth has no need, or else presenting it in such ways as to cover up the real need."[2]

These words of Professor Dewey are indicative of the reform so popularly advocated today. The movement is by no means a new one. In the field of science, it had many admirers in the days of Ferguson. To come to a more recent period, we find Henry Kiddle, who was superintendent of New York City schools from 1870 to 1879, attempting to give the child a broad survey and definite understanding of those phenomena vital to him, to prepare him for "dealing with real situations." Seaver, superintendent of Boston schools, a couple of years later strenuously opposed formula studies and showed his contempt for pouring words into students instead of taking their experiences and building upon them. In his report of 1881, we read: "How many of our textbooks begin, not with the suggestion of concrete illustrations, but with abstract definitions, and still more ab-

[1]Abstract of address given to the Physics Club of New York, January, 1913.
[2]Dewey, *Schools of Tomorrow*, page 4.

stract 'first principles'—blind guides to the blind teacher, and sources of perplexity to teachers who are not blind."

In 1904, Dr. Balliet organized a science course at Springfield, Mass. He drew his material from local environment and from those things associated with the interests and experiences of the pupil. The qualitative side of experiments was emphasized. He aimed to give a minimum of principles and a maximum of applications, to enable the child to interpret his physical environment. During the past decade, attempts similar to Dr. Balliet's have been carried on all over the country. The most recent endeavor to overcome the aversion to learning which Professor Dewey speaks of, is found in the introduction of the project method in science.

At the beginning of this school year, I was asked to take a sixth-year class of boys in the Horace Mann School and give them general science in accordance with the suggestions set forth by Professor Woodhull in "Science Teaching by Projects."[3] This, to my delight, meant that there was to be no textbook used as a text, no outline of a course of study. I want to confess that up to this time I had had little experience with boys of this age. In order to get a start, I distributed sheets containing a list of suggestive projects, and asked the boys to report on library cards the three (their own or a choice from the list) which appealed to them most from the viewpoint of either interest or importance. Projects such as the following were suggested: Refrigeration, Mining, Coal and Its Uses, Rock Formations, The Universe, Sun and Moon, Tides, Submarines, Airships, Flies, Sewage Disposal, Butter Manufacture, Sugar Industry, Incubating Chickens, Clothing—Textiles, Dyeing, Motors and Dynamos, Wireless, Telegraph and Telephone, Life of Edison, Pasteur, Faraday, etc. It was not surprising to find that the submarine was the first choice, due, undoubtedly, to the fact that it was being discussed in the press so widely at that time. When the project was complete—for us—the boys knew as much about Archimedes' principle (though that term was not used) as any intelligent youth need ever care to know. The kind of power used, the importance of the storage battery, the possibilities for ventilation and the method for stepping out of a boat under water were some of the subjects discussed. The question of periscopes arose, as a result of which most of the boys voluntarily constructed models at home, and through this, I am con-

[3]School Science and Mathematics, March, 1915.

vinced, acquired a valuable understanding of reflection of light.

It was just about this time that I had occasion to teach pressure of fluids to a class of college students. I might add that this college course aims to give practical explanations of physical phenomena, avoiding all detailed and intricate side issues. But in spite of all efforts to thus simplify the work, it took some little time to get an answer to the question: "How much pressure would there be on a water faucet fourteen feet below the tank?" On the other hand in discussing with the twelve-year-old boys the curved shape of the submarine's cross section, I made the same statement to them that I had made to the college girls the day before, namely, that a column of water one foot high presses with a force of approximately one-half pound on each square inch of surface. Upon asking the boys how much pressure per square inch there would be if the submarine were a hundred feet below the surface, there was no hesitancy in their shouting the answer. Can this contrast be attributed to anything but the factor of motivation, problem, project, interest, which was present in the one case and not in the other?

In "American Traits," Dr. Münsterberg writes: "I still remember how my father spoke to me when I was a boy of twelve. I was insisting that Latin would be of no use to me, as I should become a poet or a physicist. He answered: 'If a lively boy has to follow a country road, it is a natural and good thing for him to stroll a hundred times from the way and pick flowers and run for butterflies over the fields on both sides of the road. But if we say to him, "You need not keep the road, follow your butterflies," where will he find himself at nightfall?' "

Time and again we hear of students who cannot keep to Münsterberg's country road—formal schooling. And often these students in later life prove themselves to be extremely capable; yet in spite of their ability to overcome obstacles of every sort they were not able during their school days to cope with the hardships of following the selected path. The main road, the one built by tradition, the present course of study, is not necessarily the best. Sometimes young men are given opportunity to chase butterflies, and in so doing not only pass through more beautiful fields, but avoid many unnecessary curves of the road and attain sooner the true goal Münsterberg is striving toward.

To return to the work at the Horace Mann School: This week we have been studying forests. Lantern slides, borrowed from the American Museum of Natural History, played an important

rôle. Some of the boys wanted to "chase butterflies" and set out to do some research work. Some one says, "Twelve-year-old boys doing research!" But we cannot doubt that this is the age most responsive to the suggestion to inquire; most receptive to the answers to "why" and "how." Here are some of the topics they related in class: "Sawmills;" "Gathering and Preparing Maple Syrup;" "Experience on a Lumber Raft;" "Dangers to Trees."

The class meets, fortunately, in the Teachers College physics lecture room and laboratory where the boys have opportunity to get acquainted with all sorts of appliances before, after and sometimes during class. They pass from hydraulic ram to water motor, from automobile to dynamo, from pumps to gas engines, steam engines and storage batteries. This gives them a first-hand knowledge of the essentials of science. In the same way, they are encouraged to gather information outside of school and collect clippings from newspapers, magazines and advertisements which are then kept in their notebooks.

The course follows the path of the boys' natural desire, but they are restrained here and there from following material which, in so far as I can determine, appears to be of little value to them. In contrast to the criticism Professor Dewey makes regarding older methods, these boys are not averse to learning and there is seldom a time when interest lags. Moreover, I find that what they learn is not a veneer soon lost.

Following is a list of theses on general science, summing up one attitude toward a course in this science.

1. General science endeavors to give to all pupils a genuine understanding of everyday phenomena, leaving for later study, by those who wish to specialize, the highly organized, special sciences.

2. It aims to supply a fund of useful information and solve general problems, thus engaging whatever sciences it will.

3. It should, wherever possible, create a curiosity on the part of the pupil. This curiosity should be satisfied in some cases by information from the teacher, in others by further observation and suggested readings.

4. It trains pupils in habits of investigation, of clear thinking, and of application of acquired knowledge to useful ends.

5. It should deal with the common scientific environment of the youth and center itself about the interests and desires of the pupil, the teacher at all times keeping in mind the unity of the whole.

6. The method should be by projects, which may cover a period of one hour or extend through several weeks.

7. Tendencies to be avoided:

(a) An eclectic course of a little from each of the sciences as they have been arbitrarily defined by man.

(b) Believing nothing in science is educational unless it is thorough.

(c) The slavish use of crystallized general science in the form of a textbook.

SOME PRESENT LABORATORY METHODS INDICTED.

By I. J. Mathews,
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Present methods of conducting laboratory work seem to include some absurdities. Eminent educators argued that the inception of the laboratory method of teaching would develop ingenuity and facilitate scientific reasoning. Now, this way of teaching has been in vogue for some time, yet the product turned out is neither more ingenious in his action nor scientific in his reasoning than the individual developed by the old school of education. Unquestionably, the laboratory method is a latent force that may stimulate the development of a more intelligent and ingenious citizen if conducted under correct conditions.

So far as my own laboratory work goes, so far as I have observed the laboratory work of others, and in so far as laboratory manuals have been perused, present ways of dealing with a pupil in the laboratory are quite similar to tactics pursued in fattening a goose. Let us imagine that the goose is caged. We prepare a pill and push it to him, expect him to swallow it and call it good. If he gets fat, we count ourselves fortunate, and if he remains lean, we say it was just our luck. Similarly, let us picture the student in the confines of the laboratory. Do we tell him what is to be done and then allow him to so arrange materials at hand that he attains the goal? Do we ask him to do any constructive thinking, reasoning from the known to the unknown? Upon your life, we do no such thing! We penalize ingenuity and curb any outcrop of methodical reasoning if it does not coincide with our own. We put into the hands of the learner a set of printed directions with glaring offsets as follows: TITLE, OBJECT, APPARATUS, METHOD, SKETCH, CONCLU-

SIONS, etc. We say what is to be done, how it is to be done, what materials should be used and what conclusions should be reached. This statement may incite some quibble regarding the so-called "thought questions" that are often asked under the heading of conclusions, but really these interrogations usually dictate their answers. Is there any incentive for development of originality? If the boy puts the apparatus together any different than is specified in the directions, he is promptly reminded of the trail already blazed. Any chance for logical conclusions? Not a bit! What worries the pupil is how to manipulate the material so that the result indicated in the manual of directions will obtain.

Then, again, why all the writing? The usual laboratory method is thirty minutes of work and an hour of writing. Educators have tried to justify this writing by two reasons: (1) It may impress the operation more firmly on the mind of the learner, or (2) it may make a permanent record to which the child can refer. Both these reasons are askew from actual fact. Experience in conducting laboratory work leads me to believe that the impression of the experiment is made more lasting by doing the experiment three times, rather than doing it once and writing it up in twice the time it took to do it. A little memorandum is good, but too much writing defeats its own object. Nothing could be sillier than to believe that the notebook will be used for further reference except in very few cases. I pride myself on the notebooks I kept in physics and chemistry, but now these notebooks are curios and occupy no very important place on the shelves of my reference library. I have never looked inside the covers of either book unless it be to show how much pains I took with the drawings.

To be perfectly frank may not always be well, but just among us teachers of laboratory subjects, it appears to me that most of the writing in the laboratory notebook is a force for keeping the student busy rather than a matter of lasting impressions or the development of a valuable reference book. I have been guilty of having experiments painfully "written up" to keep the students busy. Was I alone in this? The educational value of such a procedure is, however, something less than zero. Is it not possible for us to plan our laboratory experiments in such a way that they will truly mean the development of ingenuity and a training in systematic reasoning? In addition, the requirement of painfully written descriptions is one that can stand a great amount of introspective scrutiny.

THE FUTURE OF CHEMISTRY IN THE HIGH SCHOOL.[1]

By Robert H. Bradbury, A. M., Ph. D.,

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I. The Present State of the Methods of Chemical Instruction.

There is much justification for the current indifference shown by many teachers toward the general theory[2] of the learning process. Educational speculation is an undifferentiated product, in which the valuable contributions of sincere thinkers are mingled with the voluminous nonsense of the lay critic, and with the distorted statements of intellectual acrobats who are trying to struggle into the spot-light by exploiting some phrase which happens to have caught the attention of the multitude. As Prof. James remarks—in quite another connection—the result is that we "feel it all as one great blooming, buzzing confusion."

However, contempt for theory is an undesirable attitude on the part of any craftsman or artist, for theory is usually intensely practical. Teaching is a very old profession, and it is most unlikely that ages of occupation with it have produced no valuable deposit. The teaching of chemistry, on the contrary, is a novelty by comparison. Laboratories in the universities date only from the work of Liebig at Giessen; in the high school, they are a thing of yesterday. While the teaching of Latin and of the mathematical branches is probably on a reasonably permanent basis, so that evolution, but not revolution, may be expected, the methods of teaching chemistry have hardly taken shape at all as yet.

The inchoate condition of methods of chemical teaching—and let me insist that this is wholly natural, and is due simply to the newness of the subject in the schools—is most manifest in the fact that the textbooks still handle the subject by the *analytical* method, a plan which has run through its devastating career in most nonscientific subjects, and which, like the measles and the mumps, is distinctly a disease of childhood. That is to say, the book analyzes the subject into its logical elements. These, for our science, would be electron, atom, molecule, matter, energy, solid, liquid, vapor, phase, crystal, substance, and so on. These are then

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[1] An address delivered before the New Jersey Association of Science Teachers.

[2] I have elsewhere remarked that this word is used in so many diverse senses that it is desirable either to drop it, or to standardize its meaning. In the present paper, the word "theory" is used to denote the more abstract portion of a subject; that which is reached rather by reflection than by immediate apprehension.

defined in such a way as to make it possible for the child to pretend that he understands them. If the method were employed in a thoroughgoing fashion, the periodic law, also, as a highly general concept which could "usefully be employed later," would be expounded at the outset. The residue consists in the formal treatment of the subject matter according to these categories, the familiar applications of which come last in order.

Instead of offering any comment of my own on this inverted procedure, let me intercalate a paragraph from John Dewey, who sums up the matter in a masterly way:

"What is conventionally termed logical (namely, the logical from the standpoint of subject matter) represents, in truth, the logic of the trained adult mind. Ability to divide a subject, to define its elements, and to group them into classes according to general principles, represents logical capacity at its best point reached *after* thorough training. The mind that habitually exhibits skill in divisions, definitions, generalizations and systematic recapitulations no longer needs training in logical methods, but it is absurd to suppose that a mind that needs training because it cannot perform these operations can begin where the trained adult mind stops. *The logical from the standpoint of subject matter represents the goal, the last term of training, not the point of departure.*"

As a matter of historical fact, the analytical method gives most unsatisfactory results in practice. Its prevalence is followed by a reaction, which goes to the opposite extreme. All logic, all abstract thinking, all generalization, are to be excised. The stress is to be laid upon the mental habits and predispositions of the student, and upon his environment outside of school. It is most interesting to note that this reaction against the analytical method in high school chemistry is just now in full swing. We are to "cut out the theory from the subject," the term "theory" being employed apparently as a convenient inclusive designation for anything which necessitates vigorous reflection. The retort, the beaker and the balance are to be cast out, and "mother's oven," the teakettle and the nutmeg grater substituted as the new symbols of educational endeavor. Each child, urban or not, is made to fill a bottle at the kitchen faucet with the home water, to be brought to school and tested with silver nitrate for "sewage," for nothing so abstract as a chlorine ion must be mentioned. It is sometimes objected that, in cities, this is a waste of time, since all the samples would be the same. This objection seems to be very badly founded, for, in the hands of the high school beginner, the identity of samples is no bar to the most exuberant diversity of results.

This movement is sometimes called the "grease-spot chemistry," on account of the central role played by making spots of oil on muslin and taking them out again with gasoline. The humble fruit

spot is less popular, on account of occasional difficulty in removing it, especially from colored fabrics.

I welcome the grease-spot chemistry, and perceive in it elements of great promise. True, many of the subjects taken up are somewhat trivial, and of such a nature that the student's mother could inform him more accurately and expeditiously than can his textbook.

That the "new chemistry" is only dimly aware of its own aims and purposes can be gleaned from a study of the books written to guide it, of which there are several now on the market. One would expect them to discard the analytical method, and it is not a little surprising to find them, instead, carrying it to a degree which may be fairly called a *reductio ad absurdum*. The formal logical abstractions of the science are hurled at the student *en bloc* in the first hundred pages, which form a kind of Liebig's beef extract of chemical science. Technology occupies the remainder, and the connection between the two portions is of the loosest description.

II. The Principles Which Form the Basis of the Present Paper.

But we have run amuck long enough. It is time to become constructive. Let me state, merely because I need them, two maxims which, taken together, make up a thumb-nail pedagogy. There is nothing novel about them. They are not slogans which originated yesterday and will be forgotten tomorrow, nor are they bits of euphemistic, alliterative cant. One, at least, was known to the ancients, and very likely the other also; at all events, it is equally unquestionable.

(a) "Teaching should proceed from the familiar to the unfamiliar, from the easy to the difficult, from the concrete to the abstract." Does the maxim seem unnecessarily wordy? If so, chop it off right behind the ears after "unfamiliar," and you will not mangle the sense seriously. However, the familiar is not always the easy, if the treatment is to be at all exhaustive. The boiling of an egg is familiar enough, yet Emil Fischer, in spite of his marvelous work on the chemistry of the albumins, would refuse to explain exactly what happens.

The last phrase, "from the concrete to the abstract," adds something to the meaning. The concrete is that which is immediately apprehended without effort, and without any chain of reasoning connecting it with anything else. The words, man, knife, book, are

typical concrete terms. The abstract, on the other hand, is that which is more or less slowly comprehended by a train of reflective thought, based on its relation to other things which are more familiar. Atoms, molecules, oxygen, solution, are abstract to the beginner, while a term like potassium chlorate is neither concrete nor abstract, but mere jargon, wholly incomprehensible, since by no reflective process can he acquire a conception of its meaning.

Evidently, things which are abstract and strange to one person may be concrete and familiar to another, or even to the same person at a later stage in his career. To one who has looked, in the ultramicroscope, at the particles of a colloidal solution being driven hither and thither by the molecular impacts, the conception of molecule becomes concrete. Even the electron acquires a measure of concreteness when it is fired into the ionization chamber of an electroscope, and manifests its presence there by the kick of the projection of the fibre on the screen. It is plain, also, that the concrete is at first largely the useful—which is sure to be familiar —and that a great part of education consists in the graduated logical conversion of the abstract into the concrete.

And now let us glance at school chemistry in the light of this ancient principle. What are we to think of our introductory chapter, with its rapid definition of one abstraction after another "to clear the ground"? What of the attempt to explain processes which are themselves abstract, at this stage, by the aid of substances which are not even names to the student, since he cannot pronounce the terms used to designate them, and has not the dimmest glimmering of their meaning? What will it profit the beginner to elucidate the nature of chemical combination to him through the union of aluminium sulphate and potassium sulphate in solution to form hydrous potassium aluminium sulphate? Yet this is an actual instance. What advantage is anticipated from restricting the early part of the work to invisible gases, which the beginner cannot weigh or handle, and which are themselves abstractions to him? Air is the most familiar gaseous substance and yet, in the history of human development, it was only the other day, so to speak, that man learned that the air has weight, and it required the intellect of a Galileo to take this forward step.

I can perceive no escape from this dilemma. Either the maxim we have taken for granted is incorrect—in which case education falls into chaos, and there is no such thing as common sense—or else the problem of the most efficient plan of presenting chemistry to the American beginner remains to be solved. We are far ahea

of the other nations in the universality of our laboratory work, and in our equipment for it, but far behind some of them in the order of topics and the method of presentation.

It is for this reason that we should extend the hand of fellowship to the devotees of the grease spot. They are right in their contention that the concrete should play an important part. They are altogether at sea, however, in their desire to occupy the student entirely with the useful, the "practical"—with *facts* in other words—and to banish abstract thinking. Facts which lead nowhere, which are not concerned in any way with generalizations or with the solution of problems, are nearly worthless. Facts cannot be separated from thinking, nor thinking from facts. The jingling stock phrase, "sanitation, not meditation," exemplifies the futility of the attempt, for sanitation without profound meditation is impossible.

(b) Knowledge which has been gained with some purpose in view—whether to verify a hypothesis or to carry out successfully some practical operation seems to make little difference—appears to form an organic part of the mind. It is obstinately retained and is fairly sure to be instantly available when wanted. On the other hand, information acquired by a mere act of memory is a kind of external mental deposit, for it is relatively evanescent, and it has, moreover, a capricious habit of concealing itself temporarily when most needed.

Let me make a personal confession of a striking instance. For several years, I have occupied myself, at different times, with attempting to devise an experiment whereby my students might convert a fixed weight of copper wire into cupric oxide, in a small porcelain crucible. The idea was attractive, for the change in properties is unmistakable (a most important point in an experiment for beginners), the increase in weight is almost exactly one-fourth of the weight of the copper, and the atomic weight of copper can be neatly calculated directly in terms of the oxygen standard. *Reduced* copper, made by heating the oxide in hydrogen, can easily be oxidized quantitatively in the air, but direct oxidation, even of fine wire, gives an incomplete conversion, and, though the wire can be nicely changed to nitrate in the crucible, the ignition of the nitrate to oxide cannot be effected without loss. Many plans were tried, such as filling the crucible with asbestos fibre, sprinkling the cupric nitrate with oxalic acid, and so on, but none of them worked. Finally, I hit upon the notion of mixing the cupric nitrate, obtained by dissolving a weighed portion of wire

in nitric acid, with powdered ammonium carbonate, hoping that the basic cupric carbonate might pass smoothly into cupric oxide on heating. So far as I can recall, it was about the time that the lid of the crucible struck the ceiling that the fact occurred to me that the double nitrate of copper and ammonium had been practically employed in blasting. This bit of information, picked up from Dr. Munro's excellent report on chemical manufactures in the census of 1900, had been in my possession about twelve years at the time, but it was a mere isolated fact, acquired by an effort of memory, kept in cold storage, and quite unavailable when needed. Thus did I relearn it, in connection with a particular problem, and I shall never forget it again.

This antithesis, between erudition or stored-up learning and wisdom, which is knowledge put to work for the good of its possessor, is of first-rate importance. How can we arrange things in such a way as to cause the largest possible fraction of the learning acquired by the student to take the form of available knowledge, and not of mere erudition in cold—and probably not aseptic—storage?

Let us consider one of the most important of all chemical topics, the study of the atmosphere, which properly belongs in the very early part of the course. According to the analytic plan, which is essentially the current plan, the atmosphere is analyzed by the teacher or the text into its constituents, the properties of oxygen are communicated, then those of nitrogen, then those of the minor components, finally the nature of the air is inferred from its composition. A slightly better order is to make a brief reference to the biological and physiographical importance of the atmosphere at the start, and then to proceed with the dogmatic treatment.

The methodological or inductive way of attacking this subject, which was worked out by the great reformers of chemical teaching, Arendt and Wilbrand, and put into its present form chiefly by Ohmann, starts with the rusting of the metals. It is shown that the rusting is much accelerated by heat, which, however, is not able alone to produce it, since a folded piece of sheet copper, when heated, remains bright on the inside, although the outside becomes badly rusted. The necessity of air can be further brought out by a reference to the tungsten lamps of the laboratory, in which a metal which rusts at once, when heated in the air, is maintained in a vacuum at a dazzling white heat for long periods, without being affected.

The student heats a weighed piece of sheet copper and finds,

on reweighing, that there has been an increase. This at once suggests the addition of something from the air. It will be noted that we are following the line of thought which brought about the downfall of phlogiston and the discovery of oxygen.

Does the air, then, disappear when a metal rusts in it? Iron powder, hanging from a magnet, is burned in a confined volume of air over water. A portion of the air disappears, and the residual gas no longer supports the combustion of a taper.

What about other metals? How much of the air is absorbed when rusting occurs? A liter of air is passed slowly through a combustion tube containing hot copper, most conveniently by pouring a liter of water into a flask so arranged that the air will be forced over the copper as it is expelled. This is a demonstration experiment, unsuited for laboratory treatment. About eight hundred cubic centimeters of unabsorbed gas collect over water in a graduated cylinder. This gas can now be named, and those of its properties which are not readily accessible can be communicated.

Oxygen, as the gas which disappears in the last two experiments, can also be named at this stage. The fact that it forms a series of compounds with the metals has been exemplified, and the student's knowledge can be enlarged by simple laboratory work dealing with the heating of iron, tin, lead, zinc and magnesium. The term *oxide* can logically be employed at this time, though many prefer to reserve it until oxygen itself can be prepared. How is this to be accomplished?

Platinum is heated by the student, and silver and gold by the teacher. The lack of action contrasts strongly with the behavior of the base metals, and calls for explanation. The permanence of the lustre of these three metals is recalled, and the connection of this unalterability in the air with their uses pointed out. A little silver oxide is heated by the teacher, and the cause of the inactivity of this class of metals becomes plain. Evidently, the oxides of these metals are decomposed by heat, so that, when once obtained, they form a potential source of oxygen.

Mercuric oxide is now introduced, as the oxide of a metal intermediate between the noble and the base metals, and much cheaper than the former. The student heats, in a hard glass tube, a quantity of mercuric oxide so small that it is completely consumed. This apparently trivial point is important, not only for proper economy in the use of such an expensive material, but also on account of the fact that otherwise he will not appreciate that the formation of the gas and the metallic liquid are accom-

panied by the disappearance of the red powder. This, by the way, forms a good place to call the attention of the students, for the *n*th time, to the fact that their inevitable tendency to take too much of everything is not only wasteful, but that it frequently defeats the whole object of the experiment. Chemical supply houses should put a phonograph on the market which would automatically repeat this admonition at intervals of five minutes during all laboratory periods.

The student's knowledge of oxygen can now be enlarged with the aid of a cylinder of the compressed gas, the present method of preparing which, from liquid air, can be briefly indicated, to be explained more fully when the liquefaction of gases is discussed.

The potassium chlorate experiment should be deferred. At this time, he is without a clue to the mechanism of the production of the gas. The effort to explain the purpose of the manganese dioxide deepens the mystery. Later, the exercise forms a valuable review of combustion, as well as a typical instance of catalysis.

It is, of course, understood that the treatment broadens later to include combustion, flame, the oxides of carbon, and so on. We are now restricting ourselves to the chemical composition of the air. The close of this special topic is formed by a discussion of the work of Priestley, Scheele, Rutherford, Lavoisier, Rayleigh and Ramsay, in which the parallelism between the path followed by the course and the historical development is clearly brought out. The teacher who is in search of the best method of presenting a topic to beginners may, with great profit, study the history of the subject. It is surprising how often this indicates the best avenue of approach, though there are striking exceptions. The fact that beginners are always much interested in the historical side is also worthy of note.

Preceding this inductive-deductive study of the air, there is, of course, an opportunity for the student to acquire, by simple experimentation, some knowledge of the nature of chemical combination. It would be difficult to devise a worse experiment for this purpose than the one usually recommended—the heating of a mixture of iron filings and sulphur. The change in appearance after heating is slight, the iron sulphide is invariably magnetic, and almost any proportions in the mixture will apparently yield the same result. The usual direction to treat the mass with hydrochloric acid before and after heating adds to the confusion, for the beginner can supply no interpretation of the behavior of his olfactory nerve. Moreover, the hydrogen obtained by treating

the unheated substance with acid contains appreciable hydrogen sulphide and has a most unsavory odor. The important features of a chemical process are completely lost in this exercise, which, as questioning will show, always fails to fulfill its intended purpose.

One brilliant student of the problems of elementary teaching, Karl Scheid, employs calcite for this preliminary work, while another, Otto Ohmann, makes use of some simple experiments on the formation of the sulphides of the metals, especially of copper. The advantages are all with Ohmann's procedure. Scheid's experiments on the heating of calcite to lime, on the slaking of lime, on the dehydration of slaked lime, and so on, suffer from the difficulty that exact results are almost impossible under high school conditions. Another objectionable feature is that all three of the substances just mentioned are so similar in appearance that, barring accurate quantitative results, the evidence that a change has occurred is indecisive. The primary thing to remember, in planning this introductory work, is that we have no special sense for the recognition of chemical processes. We apprehend them only by the associated physical changes. Scheid forgets this fundamental principle. To let the student convert one white powder into another, indistinguishable from the first, has no effect worth mentioning on the development of his ideas, even if a change in weight is established. Let us be just to Scheid, however, by adding that his course is rich in suggestions of the utmost value, and that no teacher who gives it careful study can fail to derive great benefit.

Ohmann's experiment on the *synthesis of cuprous sulphide* deserves the attentive consideration of the teacher who is in search of a decisive instance of chemical change for his classes. The details are given in my *Laboratory Manual,* page 11. The original is in the *Zeitschrift für den Physikalischen und Chemischen Unterricht,* about five years back. Two of the strong points which it shares with the other similar experiments have been referred to. The results are sufficiently accurate and the change is unmistakable. A third is the fact that the change in weight happens to be almost exactly one-fourth of the weight of the copper —which presents the essence of the matter devoid of all arithmetical complications. A horn-pan hand balance is quite sufficient for the weighing. It is well to clinch matters with a more exact synthesis with No. 30 copper wire and sulphur in a porcelain crucible (ibid., page 13).

Let us return to our general principle (b). Work of this kind needs more planning than a course in which everything is communicated, but it is easier in the execution, on account of the whole-hearted participation of the students. Thomas Carlyle remarks somewhere that to sit like a passive bucket and be pumped into can, in the long run, be exhilarating to no creature. And, unfortunately, the mental bucket is far more leaky than the physical one.

We can now state the general plan of such a course. Since the leading idea is clearly set forth by Dewey, and since the application to classroom instruction in physics has been worked out by Mann, we can be brief. A problem based on some familiar occurrence is presented. Vagueness is eliminated and the problem defined by preliminary experiments. Thus we find in our typical case, that other common metals behave like copper, that there is an increase in weight, that the color of the solid formed is nonessential, and that the noble metals are unaffected. A *solution,* a hypothesis, suggests itself. This hypothesis involves certain consequences which can be tested by new experiments. *If* the darkening of the copper is *really* due to the action of the air, and not merely to heat, a folded piece of copper will not be affected on the inside, where the air has no access. These tests either quash the hypothesis for good and all, or establish it as a fact which can function as one element of a new problem. True, the air is the cause of the loss of lustre of copper and other metals when heated, but is all or only a part of the air concerned in this? If the latter, air confined over water will only partly disappear when a metal is heated in it. Just how much of the air is taken up by a hot metal? Does the air which remains differ from common air? How does it act towards a burning candle? Is there any similarity between *combustion* and rusting?

This procedure—the sensing of a problem, the limitation and definition of the problem by experiments, the inductive formation of a hypothesis, the deductive treatment of the hypothesis to obtain its consequences, and the testing of the consequences by further experiments—is simply the *scientific method,* the most tremendous weapon in the intellectual armory of mankind. When the mind works in this way, it arrives at truth, or, in the absence of sufficient data, at suspended judgment. Other modes of operation show their inherent unsoundness by yielding a chaos of divergent opinions. "By their fruits ye shall know them." Unfortunately, those who understand the method, and are able to use it, form a

vanishing minority—hence the deplorable state of the world at the present moment, for when both parties to a controversy employ the scientific method, an irreconcilable difference of opinion is unthinkable. A student who had learned the scientific method and nothing else in his four years of high school life would have spent his time to better advantage and would be better fitted for citizenship than if he had been crammed with subject matter to the very ears. If he desired to spend his time in that agreeable manner, he could almost at once learn to remove grease spots much better than the tailor's apprentice, and in five minutes he could find out more about "mother's oven" than the practical gas fitter will ever know. And above and beyond all trivial matters, he would possess a talisman far more wonderful and more precious than Aladdin's lamp, which would confer upon him the power to distinguish science from pseudo-science, assertion from proof, truth from falsehood.

No wonder that the historical development so often points out the best order of topics. To teach according to the historical sequence, to give the method of science along with its subject matter, to throw the work into the form of problems significant to the student, these are little more than statements of the same principle in different words.

(*To Be Concluded.*)

LIFE-TESTING OF INCANDESCENT LAMPS AT BUREAU OF STANDARDS.

The lamps purchased by the Federal Government, amounting to about 1,250,000 annually, are inspected and tested by the Bureau of Standards, Department of Commerce. The specifications under which these lamps are tested are published by the Bureau and are recognized as standard by the manufacturers as well as by the Government. They are used also by many other purchasers of lamps.

The lamps are first inspected for mechanical and physical defects, this being done at the factory by Bureau inspectors. Representative samples are selected and sent to the Bureau where they are burned on life-test at a specified efficiency at which they must give a certain number of hours' life, depending upon the kind of lamp. About 5,000 lamps are thus burned on test each year.

For this test, great care must be taken in the measurement of the lamps and in the adjustment and regulation of the life-test voltage.

Scientific Paper, No. 265, just issued by the Bureau, gives a complete description of the special apparatus and of the methods used in these inspections and tests. Copies of the publication may be obtained free upon application to the Bureau of Standards, Washington, D. C.

THE VALUE OF MATHEMATICS AS A SECONDARY SCHOOL SUBJECT.*

By Harriet R. Pierce,

Worcester, Mass.

"High school mathematics, which has long stood as the best example of a logically organized subject, is being psychologized, reconstructed, and reorganized in terms of the needs, capacities, and interests of the student."[1] This report is a modest attempt to express the value of the study of mathematics from the standpoint of modern psychology.

The secondary school was originally established to educate special classes. It has been growing more and more popular, till now it represents one of our most democratic institutions. To-day, we believe that every opportunity for education should be given to all children, in order that they may reach their fullest development and make the most complete adjustment possible to their social and economic environment; so that they may become moral, intellectual, self-supporting citizens of the republic whose future welfare will be in their hands.

This widening of the scope of education presents a difficult problem. The original function of the secondary school should not be forgotten as the work is extended to supplement that of the grammar grades. In our desire to give a wider education to the would-be farmer, or merchant, or mechanic, we must not forget that the world still needs broadly educated men and women. These should be provided with the best possible preparation for college and for technical schools, a preparation which should grow increasingly richer each year. We ought to do more to discover and to inspire the scholar, more to help the superior pupil. There is danger that we may drift too far from our ideal of general culture, and that the direct breadwinning power may be the sole criterion for determining the value of a subject. We want to educate "all the children of all the people," but it should be as a preparation for life, as well as for making a living.

It is claimed, that in this age so rich in objective life, we have mistaken literacy for education, that we have forgotten that true education is unfoldment, and have made it simply an outer shell. "We are growing restless, lest with these educational necessities provided, the *raison d'être* of our school system will have vanished. We are turning hither and thither to discover to what

* Read before the Spring meeting of the New England Association of Mathematics Teachers.

[1] S. C. Parker, *Methods of Teaching in High Schools.*

other uses this expensive system may be put. Because we do not know what else to do with them, our schools are turned to workshops."[2]

These conditions demand sound judgment, quick insight, wide training, and the capacity for sane, conservative readjustment. We should see our problems clearly in order to preserve the proper balance between the old and the new. Because of this change in the scope of secondary education, many new subjects are being added to the curriculum, and those already there find it necessary to justify their existence.

Professor Cranby of Yale has well described the situation "Greek has been carried out from the noisy assemblage in the agonies of dissolution; Latin has been banged into decrepitude; mathematics is tottering; grammar and spelling are prostrate, with new and uncouth shapes; blacksmithing, millinery, sex hygiene—slipping over them into the curriculum. To one who wishes to say a quiet word in this confusion, a paradox may be pardoned.

"Is it paradoxical to assert that the American attitude toward education is in greater need of a general overhauling than the curriculum?

"There are two kinds of education—one certain, the other uncertain; one direct in its applications and obvious in its results; the other indirect in its methods with effects that must be deduced from the life of the recipient.

"One education teaches him to work in order to live; the other how to live in order, among other things, to work. The first we have renamed 'vocational training;' given its ancient precepts a fresh coat of paint, and set it up as an enviable novelty; the other, for want of a more specific title, we still call a liberal education.

"These two kinds of education are complementary and equally important. Both have always been necessary to civilization. Both always will be necessary; and their respective services are defined not by theory, but by the needs of men and the times."[3]

Thus each subject must have its aims more carefully defined, and its values tested. If it remains in the curriculum, it is because its worth has been established, not because conservative educators wish to keep it there. If it must give place to some more vital subject, it is because its value has been shown to be small, not because some radical educator wishes to banish it.

[2]Edwin Shoonmaker, *The Moral Failure of Efficiency.*
[3]Harper's Magazine, May, 1915.

"Education has lagged behind almost all other activities of life in evolving a series of standards in terms of which to measure its products."[4] Our present confusion is due partly to our lack of understanding of the aim and scope of secondary education today, and partly because we have no fixed standard by which the educational value of our various school subjects can be determined. We have depended too much upon the personal opinions of educators. A scientific standard should be based upon the generally accepted conclusions of modern psychology, as to what mind is, in what its development consists, and what it means to be trained or educated, and these conclusions should be based upon scientific experiment as well as upon logical deductions.

Education owes psychology a debt of gratitude for the careful study that is being given to the learning process; for the present conception gives a much better basis for determining educational values. A little readjustment to a more modern vocabulary is needed on our part. "Formal discipline" and "mental training" are relics of a bygone phraseology. We think of mental development as "the progressive organization of a system of habits, and the continuous elaboration of a system of ideas." "What psychology offers education today is a matter-of-fact view of human nature as a set of original unlearned connections, or tendencies to respond, which are redirected and to which we add by arranging the situations of life so that new and better connections are formed."[5]

As a result of the learning process, certain specific parts of the central nervous system are modified, and future action along these lines is made easier and more efficient. These modified parts represent the content or the method, or the form in which the activity has been directed, and these parts can be used again in new associations of subject matter or of method, and the benefit of previous modifications can be transferred to a partially new activity in so far as it makes use of these parts. It is because these new associations can be formed that a general training becomes possible. "The mastery of certain subjects gives an increased power to master other subjects, but the increased power must take the form of an ideal, that will function as a judgment, not of an unconscious predisposition that will function as habit. Unless the ideal has been developed consciously, there can be no certainty that the power will be increased, no matter how intrinsically well the subject may have been mastered. With a lim-

[4]Edward L. Thorndike.
[5]W. H. Heck.

ited outside environment as a starting point and constant source of reference, the school continues to enlarge the child's experience through the knowledge and the activities of a larger environment, the epitome of that outside environment to which we desire his adjustment to be as complete as possible."[6]

With this view of the meaning of education, we shall attempt to define the educational purposes to be served by the study of algebra and of geometry in the secondary school. Or, in terms of our standard, we shall try to determine the value of the specific habits formed, of the content and of the method of the subject, and of the attitude—the feelings, impressions, points of view, and ideals—developed by such a study.

We shall not consider algebra and geometry as studied in preparation for advanced work in either pure or applied mathematics, nor their limited application to the special vocations. Everyone admits their value and utility in these lines.

It is for us here and now to determine whether or not these subjects have any value for all pupils that will justify their present place in the curriculum. We shall find our answer in terms of the habits formed, of the value of the subject matter, and of the attitudes and ideals given by such study.

Mathematical habits may be divided into those of form, those of content and those of method. Under those of form are such mechanical habits as neatness, system or orderly arrangement, accuracy, persistence, attention, and memory. Each of these may be formed as a specific habit in connection with other subject matter, but each habit is also essential to the highest success in mathematical work and mathematical material is especially well adapted to use in its formation.

Psychologists have shown experimentally that neatness in arithmetic papers is not transferred to neatness in English papers. Yet when these special habits of neatness and orderly arrangement have been formed in connection with the subject matter of mathematics and English and history and all other school work, an ideal of neatness will be formed which will influence all future work. The more varied the special habits of neatness emphasized, the stronger will be the ideal and the wider its control. Not only to aid in forming an ideal of neatness, but also for the special subject of mathematics is the habit of value. Painstaking, systematic arrangement must be associated with clear thinking.

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[6] W. H. Heck.

Mathematics is also the subject, *par excellence,* for forming habits of accuracy, since all its results can and must be verified, and since the least error in the process changes the result. The habit of persistence, the habit of holding the attention upon the goal to be reached, leads to the problem-solving attitude. In no other subjects are the goals more definite, and to see the goal adds interest as a stimulus to sticking to the problem till it is solved. We know when we get the correct solution, and the satisfaction is of great value in determining our attitude towards other problems. "I thought that I had found the biggest thing on earth when I found how to make my mind work" is the way one person described this feeling. The problem-solving attitude is also necessary for success in the study of science as well as in the affairs of practical life.

The subject of mathematics is especially suited to develop the habit of attention; for any lapse of the attention is fatal to its success.

Sir William Hamilton in his general condemnation of mathematics is forced to admit "that there is a single benefit to which the study of mathematics can justly pretend in the cultivation of the mind, the study is beneficial in the correction of a certain vice and in the formation of its corresponding virtue. The vice is the habit of mental distraction; the virtue, the habit of continuous attention." Here we do not mean by the habit of attention, that attention which depends upon some immediate interest in the subject itself, but an attention which is the result of certain organic adjustments. Here the interest depends upon the attention. It is the conscious feeling which is aroused by the organic adjustments. We do not attend because we are interested, but we are interested because we have formed certain habits by which we can put ourselves into an attentive attitude. The methods by which we make these adjustments, or concentrate our attention upon a mathematical problem, are the same as those used whenever the attention is fixed upon a given subject.

According to Dr. Münsterberg, we as a nation lack this power of concentration. "The foreigner who studies the American character will always be deeply impressed by the wonderful striving for self-assertion, self-perfection, and self-realization, which gives meaning and significance to this greatest democracy in the world. But there is one trait which he instinctively perceives in spite of all his enthusiasm in the strength and glory of the New World. He cannot help feeling the lack of accuracy and thor-

oughness, the superficiality, the go-as-you-please character of the work; and this, ultimately, always means the lack of voluntary attention. Every feature of our social life shows an unwillingness to concentrate the attention.

"Only that which can be followed without effort is welcome. The serious drama is deserted, the vaudeville houses are crowded; the serious editorials of the newspapers disappear, and the racy style wins success; the yellow press tone colors larger and larger parts of politics, and even of court and church. And what else is the meaning of it but the victory of involuntary attention and the defeat of voluntary attention?

"Human nature is indeed so arranged that the attention at first follows in an involuntary way all that is shining, loud, sensational, and surprising.

"The real development of mankind lies in the growth of voluntary attention, which is not passively attracted, but turns actively to that which is important and significant and valuable in itself. No one is born with such a power. It has to be trained and educated. Yes, perhaps the deepest meaning of education is to secure this mental energy which emancipates itself from the haphazard stimulations of the world and holds firmly that which conforms to our purposes and ideals. This great function of education is too much neglected. As a reaction against a rigid, empty, mechanical instruction, there swept over the country a wave of electivism which was meant to bring the blessings of freedom, but which did bring primarily a destruction of self-discipline. It is not difficult to foresee that much of this work must be undone. If kindergarten methods are allowed to penetrate where self-discipline of attention should be learned, the future citizen has lost his chance."

The study of mathematics is also valuable in helping to form habits of logical memory. We are told that the memory cannot be trained, for there is not one memory, but many; that everything learned is a new memory. On the other hand, we learn that memory is a property of nerve substance, the tendency of a neurone to retain an impression. The neurones in different parts of the brain must obey the same laws; so while there are many specific memories, there are methods which are common to all memory work. Wherever the habits of memory are formed, they are formed in obedience to these laws, and they are consciously formed. We do not learn how to memorize, simply by

remembering in any haphazard way. If we are to increase our efficiency in memorizing, it is necessary to learn the various methods. The memory habits formed by the study of algebra and of geometry are those from which a logical method of memorizing is developed. Other methods fail to give the desired results. The pupil is made aware of this failure, and is led to understand the laws of grouping and classifying the data, of choosing the essentials, and of repetition. A definite habit of logical, orderly association of material is formed, so that one idea will at once bring up the related ideas. While the memory is a special memory, its technique is general, and this technique should be learned in connection with the best possible material.

Among the habits related to the content of the subject are the habits of economy of thought and of clearness, brevity, and precision in expression. Mathematics is the shorthand language of abstract thought. In learning how to interpret and master its symbols, habits are acquired similar to other language habits, but here the language habits are associated with the symbols which give the greatest economy in thinking and whose use is universal. The mathematical language represents "the results of centuries of polishing and remodeling," hence it has attained great precision, and in using this abstract, symbolic language, we are forming the habits of clearness, brevity, and exactness of expression. "This precise thinking has been the inspiration and model of precise thinking in all other fields." The world's work requires the constant mastery of symbols, and thinkers are more and more trying to express laws and conclusions as mathematical formulas. "It is only in the least desired occupations that men work entirely with actual things."

Algebra and geometry furnish material that is especially well fitted to make plain the essential nature of the thinking process. Here we have a "universally valid method;" a method which is the ideal of all the sciences. Mathematical reasoning seems to be a "type of thought ingrained in the human mind." Loose, careless thinking and bluffing are useless, since all conclusions must be verified. While general power is not necessarily gained by the study of mathematics, the student may be so impressed by the perfection of mathematical reasoning, that an ideal is formed which gives a standard by which his thinking in all other subjects is consciously tested. It is generally recognized that "precise thinking is gaining ground over vague theorizing in many scientific and practical activities of the day, and elementary math-

ematics has been and is the model of precise thinking in more difficult fields."[7]

Various types of thinking are necessary to solve all the problems of life. There is one method for mathematical reasoning, another for the physical sciences, which differs from that of the biological sciences, while the psychological and sociological sciences have their own special methods of thought. Every high school pupil should know the rudiments of all these methods; for no one can take the place of the other, and all are needed if we are to make correct judgments and right decisions in all the affairs of daily life.

In order to understand the world of today, we must know something of what the world has done and thought in the past, and from this point of view alone, the subject matter of elementary algebra and geometry has a value for all. "A type of thought, a body of results so essentially characteristic of the human mind, so little influenced by environment, so uniformly present in every civilization, is one of which no well-informed mind can be ignorant."[7]

Mathematics is called the "abstract form of the natural sciences," and as their data become more exact, they are developing towards the mathematical ideal. "They assume that mathematical relations exist between the forces and phenomena, and that nothing short of the discovery and formulation of these relations would constitute definite knowledge of the subject."[8]

No mention has been made of the æsthetic and ethical values of mathematics; of its regard for the beauty of truth and its worth in securing "intellectual honesty;" nor have we shown the value of its data in developing the "creative imagination." These values alone would seem to make it worth while for all high schcol pupils to know something of algebra and of geometry.

We have tried to show that mathematics offers excellent material, often the best material, for the formation of the special habits of neatness, order, accuracy, and persistence; that its data are especially valuable to use in forming the habits of attention and of orderly association, and in learning the technique of the logical memory; that the use of its abstract symbols gives economy of thought as well as clearness, brevity and precision of expression; that its method of thought is a universally valid method and gives a model for all scientific thinking, and that its content is of value because its laws are the laws of the physical universe.

[7] J. W. A. Young.
[8] David Eugene Smith.

These habits of thought and methods of attacking problems have in them elements that are common to habits formed in other ways, and in so far as two subjects have identical elements, the transfer of training from one to the other will be possible. Since mathematics has many applications to other subjects and to life, there are many opportunities for this transfer, but the ability to make it will depend upon the mental attitudes, upon the aims and ideals which have been formed.

Herein lies the greatest value to be derived from the study of elementary algebra and geometry. The ideals of neatness, accuracy, and systematic arrangement will influence all other work. All thought expression will be more direct and clear and concise as it follows the models of mathematical thinking. Unconsciously, we shall test all our statements by the logical standards of geometry. Careless methods of work will not give satisfaction; that will come only when there is systematic arrangement and careful classification.

These greatest values, like all the greatest things of life, cannot be reduced to exact measurement. A person is bigger than the sum total of all his specific habits by just these immeasurable attitudes and ideals. What the experiments of the psychological laboratory have shown us is the great influence of the mental attitude upon the formation of the various special habits. When there is a definite thing to do with a definite purpose for doing it, the results obtained are far superior to those under other conditions. Just here is where mathematics excels other subjects, for nowhere else can such definite tasks be assigned and such clearly defined ends be given.

Since the formation of these attitudes of mind and ideals of method must be made consciously, much depends upon our insight and ability to present the subject with more inspiration, with a better defined aim, and with a clearer view of its values; so that the transfer of these attitudes and ideals to other subjects will be made possible. With competent teachers and good methods, mathematics gives a training in processes common to many subjects, and develops fundamental attitudes vitally significant in every form of mental activity.

Whenever and wherever algebra and geometry can be so taught that they give all the possible rich and varied attitudes towards life, of which they are capable, their value as secondary school subjects and their value for all pupils will no longer be questioned.

AN EXPERIMENT IN TEACHING ALGEBRA.

By Charles A. Epperson,
First District Normal School, Kirksville, Mo.

It is not usual in teaching high school algebra to introduce any of the methods of analytic geometry to explain the meaning of such equations as those of the straight line, circle, and ellipse. As a general thing, if these curves are plotted at all it is by locating points on them. The idea of making use of the slope and intercept of a line, the center and radius of a circle, or the center and semiaxes of an ellipse to plot these curves is not introduced. It was with the end in view of trying to find out whether or not the easier principles of analytic geometry would be readily understood by a class in the second year high school algebra, and of making use of these principles in plotting curves, that this experiment was undertaken.

The class was the one called the "Third Quarter Algebra Class" in the First District Normal School of Missouri. The work indicated for the class was pages 236-365 of Slaught and Lennes' *First Principles of Algebra*. The members of the class were for the most part from the rural districts of North Missouri, and had not had an opportunity to do their high school work in high school, but were compelled to come to the normal school for it. The average age of the students was eighteen or nineteen. So much for the class.

By touching very lightly such topics as highest common factor, lowest common multiple, and cube root, the class was able to cover the required pages thirteen days in advance of the close of the quarter. In their previous work, they had taken up plotting of the straight lines, the parabola, the circle and the ellipse, by means of locating points on them. I then took up in lecture the following topics in the order named—the definition of slope, to find the slope of a given line, the equation of a line joining two points, the equation of a line in intercept form, parallel lines have the same slope, perpendicular lines have slopes which are the negative reciprocal of each other, the length of a line segment, the equation of a circle when its center and radius are given, to find the center and radius given the equation of the circle, to write the equation of a tangent to a circle at a point on the circle, to write the equation of an ellipse when its center and semiaxes are given, and to find the center and semiaxes when the equation of the ellipse is given. Proofs were given to every statement except to

the one concerning the slopes of two perpendicular lines. Problems illustrating each step were solved at the board, and examples set to be handed in the next day. This was the method of the experiment.

On the thirteenth day, the following test was set over the twelve days' work:

I. (a) What is meant by the slope of a line?
(b) What is the slope of the line $2x-3y=6$?
(c) Of any line which is perpendicular to this line?

II. (a) Find the equation of the line whose slope is 2 and whose y-intercept is 6.
(b) Of the line joining the points (3, 4) and (—2, 1).

III. (a) Find the equation of a circle whose center is (2, 3) and whose radius is 6.

IV. (a) Find the center and radius of the circle,

$$x^2+y^2+2x-6y = 16.$$

(b) Find the equation of the tangent to this circle at the point (4, 2).

V. Find the center and semiaxes of the ellipse,

$$3x^2+4y^2+12x-12y = 2.$$

VI. Determine A so that the circle,

$$x^2+y^2-4x-6y = A^2-13,$$

shall cut the ellipse

$$\frac{(x-2)^2}{16}+\frac{(y-3)^2}{4} = 1$$

in four distinct points.

By considering each question of equal rank and each part of a question of equal rank, the average of the twenty papers was seventy-six per cent. If three who failed in the work be left out, the average of the remaining seventeen was eighty-eight per cent.

This is the second experiment of the kind I have conducted. The records of the first were not kept as it was very short, covering only four or five days. I have in mind several such experiments in classes other than this. For example, the following problem, "Find the locus of a point whose distances from two given points are in the ratio M : N" (Wentworth-Smith *Plane Geometry,* page 252, problem 11), could be much simplified by introducing the analytic method. The value of this kind of work, as I see it, is that it gives the student a taste of methods different from any he has known, simplifies many difficult problems, and gives to formerly meaningless equations a very definite meaning.

FUEL BRIQUET REPORT.

According to the annual statement of the Geological Survey on fuel briquetting in 1915, now available for distribution, the production during the year was 221,537 short tons, valued at $1,035,716.

MATHEMATICS CLUBS.

By Frank C. Gegenheimer,
Marion, Ohio.

The article in School Science and Mathematics for February, describing the organization of a mathematics club in one of the Chicago high schools and the nature of the work done by the club, was of special interest to me.

In our high school, with an enrollment slightly in excess of five hundred, we offer no mathematics beyond solid geometry and algebra in the third year. As this work is required of all third-year students except those who are taking the commercial course, there are, naturally, some in these classes who are not mathematically inclined. This situation presents the problem of providing something for the bright students, who can do, and who are willing to do, more than is done by the average student. For two or three years, I had desired to form a mathematics club, but it was not until this year that such an organization was attempted.

Soon after the opening of the present school year, I discovered a considerable number of students in my classes who were very much interested in their work and who were anxious to do more work than the course offered. I extended an invitation to all the members of the junior mathematics classes to meet me at a stated time for the purpose of organizing a class for the further study of mathematics. To my surprise and delight, about twenty-five students, both boys and girls, came to the meeting. I explained the plan and purpose of such a class, and all present expressed a desire to become members of the class, and at another meeting an organization was effected. The class adopted "The Mathematical Society" as its name, and elected a President, Vice-President, Secretary and Treasurer.

Membership was at first limited to members of junior mathematics classes, but very soon after organization seniors who had taken junior mathematics were admitted to membership. The club is now considering admitting to membership students in plane geometry classes who have had one semester's work, and who are recommended by their teacher. For juniors and seniors, the only qualification for membership is a desire to study mathematics.

Meetings are held weekly on Monday afternoon at the close of school. At each meeting, at least one paper on a topic of

mathematical interest is read by one of the members of the class. The members of the class present their proofs of theorems and solutions of problems which were presented by the instructor or members of the class at the previous meeting. These frequently provoke lively discussions. Members are encouraged to propose problems for solution.

The subjects of a few of the papers that have been read are: "The History and Development of the Signs of Addition and Subtraction," "The Nature and Importance of Axioms in Geometry," "Early Methods of Multiplication and Division." A paper on "Pythagoras and the Pythagorean School" was read at a meeting devoted to the study of the Pythagorean theorem. At this meeting, various proofs of this famous theorem were given.

Just now, the class is studying collinearity and concurrence. This will be followed by a study of the nine-point circle and other properties of the triangle and its circles.

The members of the class are encouraged to read articles in the magazines relating to mathematics, and to give a report to the class. The trisection of an angle is always an interesting problem for students, and the proposed solutions which appear from time to time in the magazines are examined and discussed at the meetings. At an early meeting, the problem to find a point midway between two given points by means of dividers alone created much interest and brought out much clever work. This was followed by other problems of construction by means of the dividers alone. Solutions involving fallacies never fail to provoke serious thought and lively discussion and are, therefore, of great value.

Our Mathematical Society was begun as an experiment; it is still an experiment, but I think that the continued interest of the members in this work of the society with only such organization as I have mentioned, and without social features of any sort, justifies me in the belief that a mathematics club is one of the very good solutions of the question: "What shall we do for the bright students?"

BIG JUNK PILE.

During the year 1915, secondary metals were recovered from scrap, sweepings, etc., in the United States to the value of $114,304,930, according to the annual statement on *Secondary Metals* issued by the U. S. Geological Survey. This report is now available for distribution.

HAS AGRICULTURE A PLACE IN THE COURSES OF CITY HIGH SCHOOLS?

By Irvin J. Mathews,
High School, Rockford, Ill.

If I were to say that agriculture has a place in the curriculum of every rural and village school, most people would agree, but to the question, "Has agriculture a place in the course of the city high school?" the affirmatives would probably not be conspicuous. Just what is the status of secondary agriculture in the city high school and has it any place there?

As a representative of the agricultural teaching profession and being in touch with one of the largest high schools in the state of Illinois, I have considered this question from many different angles. At the outset, let me say that there are still many unsettled details that need more time for a correct solution.

As to the needs which called for the establishment of a department of agriculture in the Rockford High School, I have no answer. In short, I do not know what forces were at work, but I am positive that many men in this city who have followed clerical work all their lives have seen the need of the coming generation knowing more about agriculture. Because a student takes the agricultural course in the high school is no reason and should not be taken as conclusive proof that he expects to be a farmer. We have got away from the notion that the only people who need to know about farm products are the people who live upon the farm. Trite as it may appear, we all eat, and our first great want is to fill our stomachs. Perhaps you never thought of it before, but there is absolutely nothing on your table in the line of eatables that did not emanate initially from some farm. Even the pepper that is sprinkled upon the food comes from a farm, a pepper farm in the Indies. Every housewife who buys potatoes ought to know when the grocer delivers scabby or diseased ones.

If one will stop to think for a moment of the health regulations that have been passed in the country, it will be noticed that we have not pursued the policy of excluding diseased products solely because we were afraid the disease would be communicated to people, but rather because of the humanitarian aspect of the public conscience. We know almost beyond the question of doubt that the meat from an animal with a broken limb will convey no disease to humans, and it is only because the animal is sick that we condemn the product. If we extend the same kind of logic to the vegetable situation, we shall see that the two are

very similar. If agriculture in the city high school does anything, it ought to lay emphasis upon healthy vegetable products, since vegetables are used in every meal. We ought to know that there is more than one disease of potatoes. Every housewife ought to know when the grocer brings beans that have anthracnose. Thus it seems that one of the greatest purposes of secondary agricultural education should be to teach the value of home wares, the value of healthy vegetable and animal products, and how to retain this quality after the food has been delivered.

We hear a great deal of grumbling these days about the high cost of living. While there are many of my good friends who infer that it is more largely a question of the cost of high living, I am not convinced that they are entirely correct in this. It is possible that we do live a little high at times, but I am convinced that, in the main, most people are trying to cut down expenses. In so doing, there is nothing that is more potent than the back yard garden. Every average lot in the city ought to have one of these gardens, and one will be more than surprised to find the great variety of vegetables that can be raised therein. More than this, besides having healthy products, they will be close at hand and may be had fresh from the garden.

I take it that one of the principal things the agricultural course should do is to elaborate on theories. I haven't taken up a farm paper in the last six months without reading about "practical agriculture." That the instruction should be made practical, I have little question, but for the idea that calls "practical" the simple slatting together of a few narrow strips of lumber to form a crude potato crate, I have little use. If that is all practical school agriculture means, my opinion is that it is worth nothing.

Let me repeat that the agricultural course in the city high school should be made practical, but I mean by this that it is to fit into the everyday life of the boy or girl who takes it. It ought to be, more than any other subject in the high school, a connecting link between the home and the school. In our course in farm crops, we are giving three weeks to the study of landscape gardening, and while I am willing to concede that we cannot do very much with this subject in the time alloted, I am not willing to concede that we cannot do anything that will be of help to the city of Rockford. Having these students when their minds are in a plastic condition, it would seem that many of the principles laid down will never be lost, and that no one who has taken this course will be guilty of filling a nice open lawn with gaudy flower beds. In our work, we are finding that city pupils

take more interest in the study of scientific agriculture than people who live in the country. The farm boy of sixteen thinks he knows all about agriculture and, until he finds out that there are a few things he doesn't know, it is very hard to get his interest.

To those who contend that such a course ought to be run in connection with land, I may say that I have considered this matter from many viewpoints, and I have talked with men who have had experience with it. If the school garden means nothing more than having each boy cultivate a rod-square garden that belongs to some one else, it has no place in the school. Boy nature demands ownership and is satisfied with nothing less.

I am of the opinion that the use of land in connection with the study of agriculture in secondary schools is a very debatable question. Not only do we have the problem of trying to make such a piece of land pay, and this is demanded by all who have anything to do with it, but we have an enormous help question to solve. The man who teaches agriculture is usually loaded up with enough studies so that he has no time to cultivate ground belonging to the school, and if he has a man working for him, this man always thinks he knows more about it than the one who supervises the work. In some cases, the instructor has tried to get the boys to do the work, but they do not like this and, while they can be forced to do it, the task is not as simple as many writers have assumed. The use of a small plot of land as a curiosity strip upon which to plant farm crops so that the students may become acquainted with them is a fairly good scheme and, from every angle that I have viewed it, this seems to me the only feasible way of using land in this connection.

I want to lay especial emphasis upon the part that the instructor in agriculture ought to play in the life of every city. One of the qualifications for teaching this subject in a town or city ought to be a working knowledge of landscape and vegetable gardening. Persons fitted only for science ought never to attempt the teaching of agriculture. One should strive to be useful, not only to school people but to townspeople as well, although I don't want to be misunderstood as saying that the instructor should allow his school work to suffer at the expense of work he does for outsiders. The first and most important essential is to work with students, but, after that is done, service to others is not an unreasonable duty. Service is the keynote of the work.

GENERAL SCIENCE IN EAST SIDE HIGH SCHOOL, NEWARK.[1]

By Flora E. Hook,

Charles H. Judd of the University of Chicago wrote the *Introduction to "General Science,"* edited by Caldwell and Eikenberry. In this introduction, Mr. Judd speaks of the unrest in the teaching of science. Those who are attempting to follow the progress of the work in the first year of science in the high schools of the United States are quite ready to agree with him. Between the strictly biological course of the New York regents where a very little of chemistry and physics is given, and the general science as set forth in Caldwell and Eikenberry's book, where physics, chemistry, and physiography enter in as a large and important part with a smaller portion of biology, there is surely a wide difference. Yet we in New York state thought we had the best course, and now at East Side I think we have a better course, and it is neither of these.

The course I am following was planned and taught successfully for several years by Dr. Grace E. Cooley, a member of the General Science Committee of the National Educational Association. The aim is to familiarize the pupil with his environment, and with the laws which govern the world; to teach him life principles by a study of natural forms, that he may be master not only of himself, but of the resources supplied him.

What constitutes his environment? The earth he walks on, the water which is so free that the very noun has become a byword, the air he breathes, and the food which plants manufacture for him. We begin our study just where man begins with the world about him.

Water is the supply which the camper in the woods looks for in choosing a spot to pitch his tent. The prospector in a new land finds his claim valuable only when he determines a safe water supply. Water is absolutely necessary to humankind. It is in every part of the world that man inhabits. It penetrates the soil, enters the plant, and is again poured out upon the earth, making the land fertile. It works through the soil sculpturing the earth's crust. Water changes climate and, wisely used, makes the desert a fertile land; recklessly wasted, its loss makes a barren expanse of sand and dust. If man had known better how to guard water, many of his natural resources would have been saved to him.

[1]Paper read before the New Jersey Science Teachers Association at Trenton, March 18, 1916.

Water is easily experimented with, so our first experiments are to show evaporation. The pupils at home watch a pint of water in a kettle on a stove. They are asked to answer the following questions:

1. How long it takes to reduce the pint to one-half pint.
2. What changes you see while the water is boiling.
3. Where the water goes and if you see it again.
4. What happens when you put a spoon over the nose of the kettle.
5. If you succeed in catching some of the steam.
6. What you learn from the experiment.
7. What you know of the Scotch boy who did this experiment in the eighteenth century and has been remembered for it.
8. How much wiser was the world for his thoughtfully boiling water.

The following day, answers to these questions are discussed and written on special science paper to hand in. As special topics to be reported on next day, the life of Isaac Watts, and the story of the first steam engines are assigned to two pupils. I found Forman's *Story of Useful Inventions* especially good for this report. The experiment performed in class to show the force of steam is very simple. The pupil boils an inch of water in a test tube over an alcohol lamp, and puts a cork lightly into the tube. Before many minutes, the cork shoots out and everyone is enjoying the experiment tremendously. Then we start our toy steam engine going to really see the wheels go round, when driven by the steam held in the cylinder.

Evaporation from the body is shown by breathing on a mirror and by holding the hand over glass. The importance to the heated body of evaporation from the skin is discussed. The cooling power of fans is explained, and the desirability of moisture in the air of the heated living room in winter. To show the cooling result of evaporation, we moisten our hands with alcohol and note the first sensation as the alcohol disappears. Application of this cooling result are given in—keeping the milk pitcher covered by wet cloths, the coldness even on a warm day of a wet bathing suit, the coolness from sprinkling the pavement and floor with water on a hot day, and the refreshing touch of lawn grass.

Moisture of the air is studied as it rises from plants in transpiration, from the ground, and from bodies of water. Just as the steam we could see came up from the kettle of water, so water is going up all the time from the surface of the ocean. Just as the vapor condensed on the cold spoon, so vapor in the air condenses when chilled by cold conditions. It may rise to great elevation, it may come in contact with cold layers of air blown from some other locality, or it may strike the mountains.

To make rain clouds more geographical, we draw elevation and rainfall maps of the United States and of New Jersey. We discuss the effect which height of land and amount of rain has had on the prosperity and commercial progress of the various regions of the United States and of New Jersey in particular.

The work of this water which falls on the surface is then studied as water making changes in the earth's crust. Several simple experiments are given to show the solution work of water in the soil and at home. Springs, wells, artesian water, geysers, and caves show the various phases of ground water work. A great many pictures are used to illustrate these topics. The pictures we cut from magazines and railroad time-tables, and mount them on cardboard. Other pictures are loaned us by the Newark City Library. The action of frost in the ground, erosion by running water, buyoant force for transportation, and power for machinery are brought into this study of water.

To complete the study of water and to introduce the study of living things, we start the growth of seeds in water at home. Other seeds are grown at school in three-inch vials in wet sphagnum moss, a vial prepared and labeled by each pupil. Later, when we study the cell, we use these little glass vials of seedlings to show the work of the living root hair cell in selecting food for the growing plant. How living matter takes in water is shown by the experiment with the egg, the transfer of water from cell to cell by hollowing out a carrot and filling the hole with dry sugar, how water rises by the celery stalk in red ink solution.

To form a connecting link between our study of water, the cell and its work, and the topic, "Food," we examine our seedlings grown in spagnum moss. We find the change in the seeds which has resulted in a little plant with root, stem, and bud. This change was due to water and food.

Where do we get food for our growth and development? Largely from plants. So we make a list of the food plants grown in New Jersey and a list of the industries dependent upon agriculture. We try the food tests, and learn what each nutrient gives to the chemical composition of protoplasm. We learn what the body requires in calories according to age, work, and climate. A thorough study is made of the value of all of the common foods for protein, carbohydrates, or fat. Colored food charts showing the celery, loaf of bread, or chop, divided into its protein, carbohydrate, fat, and water content are especially helpful in this

work. A very definite work is done in the study of balanced diets; and the common errors in our present-day choice of foods are discovered. We look through the lists of food tables in Sharpe's *Manual,* and the pupils bring twenty-five or more of the one hundred calorie portions of baked apple, boiled potato, peanuts, bread, crackers, meat, etc. Then menus or meals (which shall be well balanced) are chosen from the foods on the table before us. The lists printed daily for the school lunch counter are discussed in class for balanced lunches, and economy in food chosen. We have an excellent domestic science teacher in charge of this work, and her well-prepared dishes form an attractive part of this study.

We study foods also to practice economy in the purchase of the family needs. The present-day price of all the common foods is learned in order to choose those which are most valuable for protein, carbohydrate, or fat content, and at the same time reasonable in price. Buying food by package and by bulk is compared for the actual number of ounces obtained for the same sum. We found oatmeal, saltines, and graham crackers were cheaper by bulk. Italian macaroni was not only cheaper but showed a greater protein value than the other makes. We find a common error in economy is buying food out of season and buying that which is never plentiful in our locality. One boy wisely insisted that the best economy is practiced when you do the marketing yourself.

Finally, we study food adulterations, the cleanliness of the shops where food is sold, the protection of foods from dust, flies and from handling by customers. A report is written by each pupil on the good qualities and bad of the shop where his parents purchase supplies for the table. Here we made good use of the interest in the subject under discussion to emphasize the useless expense to the citizen of alcohol. It cannot be considered a food, and only impairs working power, makes subjects for prisons and insane asylums. Tobacco is discussed for its effects on scholarship.

We have made a practical study of food. Now we wish to know the source of all these nutrients. We found all were present in one plant or another. How did the plant make them? What does it have? Just soil and water and air.

Air has not been studied as yet, and now we are all ready for it. Its composition is explained and some of its properties illustrated. The pupils put an inverted glass down into a bowl of

water and find that air occupies the space in the glass and keeps the water out. A bottle full of water is covered tightly with a paper and inverted. The paper stays on and holds the water in, proving the pressure of air all around. We study elements and compounds to understand the composition of water, carbon dioxide, and starch. We show chemical change by simple experiments in oxidation. The source of carbon dioxide we find to be oxidation of animal bodies, and of fuel of various kinds, and decay of food materials.

Now we have the materials for starch-making—that is, carbon dioxide and water. And we find photosynthesis going on in the green leaf under the sun's rays is not such a difficult thing to understand. We also prove how helpful our shade trees, shrubbery, lawn grass, and flower gardens are as sources of the all-important oxygen in a busy city. Protein and its manufacture proves we must have the element, nitrogen, which we discover is in the ground as the result of decay of organic matter and of the work of nitrogen-fixing bacteria. The interdependence of plants and animals has been brought out in the process of starch-making by the plant and of breathing by animals. This mutual assistance is still further proven by the decay of organic matter for protein manufacture. Plants and animals must exist for each other.

How is unused material restored to a form useful to the food factory—that is, the green plant? By bacteria in decay. The leaves, stems, and all plant and animal structures which fall to the ground are besieged by hundreds of microorganisms which reduce them in decay to solutions and gases that may be taken in by the new growth of active plants. So we study bacteria for all the uses and harm that they are, their work in agriculture, in dairying, tanning, and linen preparation. We prepare Petri dishes with gelatin, expose them to various conditions, as air of the room, dust of the floor, pencil point, and finger nail. Even without an incubator to keep them warm, the cultures develop colonies within a few days. This gives us an opportunity to emphasize all the tremendously important facts of personal cleanliness, and sanitary conditions in the home and city. The more common contagious diseases are briefly diagnosed. Especial emphasis is given to tuberculosis, its cause and means of spreading, and effectual methods of preventing it.

Sanitation of the city leads us to a definite study of our own Newark water supply, sewerage disposal, garbage disposal,

and street cleaning. Newark has a water supply which is excelled by that of few other cities. The city owns a large part of the Pequannock watershed where the water for the city falls on land carefully guarded from pollution by dwellings of any kind. Thousands of young trees have been used to reforest the hills to ensure a constant supply of water free from mud and surface washings.

The milk supply of Newark is one in which the city takes pride. The farmers who supply the city have cooperated in giving a safe product. The stables are judged by a card of points. Before license is granted, a certain number of these points must be credited to the owner of the cattle. Cement floors, specified amount of air space per cow, amount of light, whitewashed walls and ceilings, food of the cow clean and healthful, water supply to the stable pure and abundant, are some of the items included. The cattle must be tested with tuberculin within a year, and defective cattle removed. The milk shed must be separate and provided with ample supply of running water, and with cooling and bottling apparatus. Finally, the milk is to be sold after June 1st only in bottles and by grades; and the cap must tell the grade of the milk, the date when bottled, and the name of the man responsible for the milk.

The parks and playgrounds of Newark are another interesting topic of study. East Side Park, which our school faces, is given special attention for the number of people who are seen in it in one-half hour of a favorable day. The pupils draw the plan of the park, study the map of the city, and decide where additional parks or breathing spaces are much needed.

In this way, we have located each pupil in his own community during the 1B term. We have tried to make him understand his environment so clearly that he will feel personally responsible to help to keep his ward free from rubbish, to insist upon healthful food sold in a sanitary way, and to defend all parks and playgrounds which will make healthful retreats for the many people of the city.

In the second or 1A term, we devote one week to the study of the Paramœcium as a one-celled animal living in an environment of water and food. It takes building material from the liquid around it. There, too, it finds oxygen and energy-producing nutrients for its protoplasm. To this liquid it returns waste, and the water carries it away. Just so the cells in the body of man are surrounded by lymph. From the lymph they take their

food and oxygen, and to the lymph they return carbon dioxide and nitrogenous waste which is carried away.

In the eight weeks devoted to physiology and hygiene, we study the skeleton to be able to keep it from becoming deformed by wrong shoes, by poor standing and sitting positions, and by bad position while at work. We are interested in muscles as we find them in our own bodies. Are they evenly developed? Are they healthful enough to give us pleasure in out-of-doors life? Have we cramped them by clothing or poor position so that we are not normal? What can we do to correct the wrong we have already done ourselves? Do the muscles of our faces and the way we carry ourselves reveal our ideal of manhood and womanhood? Would we be given a position on our looks? One girl, after a study of her own face in the mirror, decided she was frowning too much, and in a month's time I have seen her forehead show decided improvement.

In digestion, we study our own mouths with a mirror to learn how they are adapted to the uses which we have for them. We find out defects in teeth which could be corrected. By experiment, we learn what nutrient is acted upon in the mouth, and so what foods we must give plenty of work by the teeth and tongue. The influence of states of mind on digestion we find is important —why we can eat heartily at a picnic when we are having a jolly time, and can hardly force ourselves to eat when we are worried over examinations. We found the book by Luther Gulick, called *The Efficient Life,* valuable for this work of digestion. For illustrative material, we got tripe, pancreas, and liver from the market.

In studying circulation, we examine blood from our own fingers, look at the network of blood vessels under our own tongues, and take our pulse from the wrist or a spot over the ear. Fresh heart and lungs from the market show the pulmonary artery and veins, the aorta and vena cava, and the muscular structure of the heart. A good work is done in studying the causes of colds in congestion, and the cure in relieving the congestion by continuous warmth and rest. First aid to the injured work with real square knots, real bandaging, and antiseptics to use, brings our study down to everyday life.

In connection with the topics of respiration, we use the model of diaphragm and lungs as given by Sharpe's *Manual.* It consists of a bell jar covered at the bottom by a rubber diaphragm,

and containing at the top a cork perforated to hold glass tubes with rubber lungs at the lower ends. After we have learned the facts about the structure and use of the air passages, we take a trip over the building to study the ventilation of our own school. The janitor goes with us from roof to basement, and explains the whole system, while we decide for ourselves on the good and bad points of its action.

Our work on the nervous system I think is quite valuable. We study first the eye, ear and sense of touch in order to under stand that the material for our minds to work upon is what we see, hear, and feel; and that we can train ourselves to see much more in a day's life than we do, to hear more that is for our pleasure and profit. Then we study the structure and work of the brain from its various phases. By following the work given in Frances Gulick Jewett's *Control of Mind and Body,* we are able to get a simple understanding of memory. We take a difficult piece of literature and build bridges of association from the vague words to our own knowledge, and so make that piece of literature ours by memory. We trace the formation of habits in our own lives to show their help and hindrance. Finally, we find we have the power of choosing in part what shall enter into our own lives and thus discover what our characters are.

In the spring, when the season for such work comes, we take time for a study of soil and gardens. The pupils bring a sample of the soil in their prospective gardens and sift it through two grades of wire gauze to determine its proportion of coarse and fine material. They weigh out a certain part and burn it to show the organic matter in it, and test another part with litmus to show its acid or alkaline property. Then they bring plans of their lot to show the space where there may be a garden. A great many pictures of flowers are studied for the selection of those best suited to the needs of each garden. A plan of the garden is drawn with the flowers and vegetables rightly arranged. We send to the Boston School Garden Association for seeds, each pupil marking his own order envelope and inserting the money. Last spring, one of my boys took a city prize for his garden. We are hoping to have even greater success with the plots this spring.

The last seven weeks of the 1A term are given to a study of flowers and insects for the purpose of understanding life principles. By flower structure, we develop the steps of reproduction, and that leads us to the tremendously interesting results of Luther Burbank's experiments in plant breeding. We see the con-

trol which this scientist has over living plants at his hand, and come to realize that, after all, the world was made for man. From the wild flowers like the butter and eggs, we learn how the plant which has adapted itself to conditions favorable to insects has been successful in making many strong seeds and so has won out in the struggle for existence. Just so when man makes himself a useful individual in the community, his own success is the more certain.

In our work on insects, we study the harmful and useful ones found in home, storage houses, garden, and trees. We learn the life histories of a few of them like the house fly, mosquito, tent caterpillar, cabbage butterfly, dragon fly, bee and beetle, to be able to destroy or help them more effectively. Riker mounts of these are a valuable help in visualizing them. A field trip or two is a help and stimulus in this work. Each pupil is given a shell vial and cork to collect flies early in the spring, and a record is kept of the number each brings in during the months of April and May. (All of the first-year pupils, both 1B and 1A, are interested in this work of collecting flies.) Then the types of insects are studied, which show them winners in life's race. The ant colony and the hive of bees are excellent types to teach division of labor in a community. Each one of us has a certain work to do. Do we steer as straight for it as the bee does for the hive? Are we systematic and orderly as the ant is? Even the thumpy old June bug, making a fool of himself around the flaring lamp. can teach us some things we do not want to do.

GEODETIC CONNECTION BETWEEN MEXICO AND THE UNITED STATES.

The Secretary of Commerce announces the completion of the work at the Rio Grande to the westward of Brownsville, Texas, and Matamoras, Mexico, which connects the triangulation systems of the United States and of Mexico.

In the United States, the arc of primary triangulation extends from the northwestern part of Minnesota southward along the 98th meridian to the Rio Grande, and Mexico had extended an arc of primary triangulation along the 98th meridian from its Pacific coast to the Rio Grande.

Mr. E. H. Pagenhart of the Coast and Geodetic Survey and Mr. Silverio Aleman of the Mexican Geodetic Commission, in April and May, made the observations from towers erected on both sides of the river and the work was successfully completed. The length of the completed arc is 2,270 miles.

This is a notable event in the history of geodesy and will make it possible to have the maps of the two countries harmonize at the border.

THE PRESENT STATUS OF ZOOLOGICAL TEACHING IN MICHIGAN HIGH SCHOOLS.

By Harold Cummins,
University of Michigan, Ann Arbor.

A number of papers dealing with the aim, content and method of zoological instruction in the secondary schools have appeared in recent years, and there have been several other papers which discuss the results of state surveys of conditions in biological teaching. While in these papers present conditions are adversely criticized, few solutions are offered for the problems set. Neither do many of them present practicable suggestions for improvement. With these criticisms and problems unanswered, it seemed desirable to undertake an investigation of the status of zoology in Michigan high schools, having in mind the collection of data which would at least offer a ground for constructive criticism. It was necessary to confine our efforts to a relatively small part of the field—the content and method of laboratory teaching. The field was further narrowed by limiting the study to accredited public high schools in Michigan. The investigation was carried on through a careful study of data received in reply to the two questionnaires which are reproduced below.

In February, 1915, the first questionnaire with explanatory letter was mailed to the instructor in zoology in each of eighty-six accredited high schools which, from the available records, were believed to offer courses in zoology. Replies were received from fifty-four schools. On finding that further information was necessary, the second questionnaire was prepared, and sent to each school which had replied to the first. Of these, thirty-one schools replied. There are, according to the last published inspector's report, 241 accredited schools in the state. It is assumed that the schools studied are representative of the schools throughout the state. That this assumption is not unjustified is evidenced by the location and enrollment of the schools studied as indicated in the list (v. infra).

Not all the answers in each questionnaire were usable. Under each heading, therefore, the number of schools from which good data were received is noted. The answers obtained from both questionnaires form the material upon which our conclusions are based. In addition, some facts were gained from discussions with teachers individually, and from the general discussion following a presentation of this paper before the Biological Section of the Michigan Schoolmasters' Club.

QUESTIONNAIRE I.

(Subjects that we have not considered in our discussion on account of incomplete or unsatisfactory answers are preceded by the symbol, "‡.")

City .... Name of school, ..., Number of students in school ....

Instructor in zoology. What other subjects do you teach? ....

Number of sections in zoology .... Usual number of students in each ....

Is there an advanced course in zoology? ....

Grade of students who take zoology .... Is the course required? ....

Is the course given every year? ....

Number of periods per week in recitations .... Length of period ....

Number of periods per week in laboratory .... Length of period ....

Text used ....

Laboratory manual used ....

Do you write your own outlines? .... How given to students? ....

Are botany and zoology elected as separate courses or combined as biology? ....

Number of weeks spent on zoology alone ....

Is a course in human physiology taught in your school? .... (a) As a separate course, or (b) in connection with zoology? ....

In the laboratory do you make a study of types? .... If so, what types, and in what order taken up? Is a mammal included? Describe the character of work done on each type (anatomy, movements of living forms, etc.). This group of questions should be answered fully on back of this sheet. If not a type course, describe it fully.

In the laboratory, do the students work independently or do they require much help? .... Does the teacher give individual assistance?

Upon what phases of zoology do you place special emphasis? ....

Do you emphasize the evolution of animals? .... How?

State the amount of field work done as a required part of the course, and on what animals. Does the class make any voluntary trips outside of regular hours? ....

Amount of outside reading required and the nature of it ....

‡Do the students appear to be more interested in zoology than in other studies (history, mathematics, etc.)? ....

‡How is this interest manifested (by large classes, collecting, interest in bird study, etc.)? ....

Do you have a museum collection for demonstration? ....

Briefly describe it on other side of paper. ....

Do you find that seeing specimens of the various animals described in text increases the students' interest? ....

‡Number of compound microscopes in laboratory .... Dissecting 'scopes .... Prepared slides .... Amount and kinds of glassware ....

‡Do you feel that the course as now given is satisfactory? .... Or would you suggest any changes? ....

‡Is your course limited by any provisions of the school authorities, or otherwise confined within certain limits? ....

‡Is nature study taught in the grades? .... What grades?

‡Is it good preparation for your course? ....

QUESTIONNAIRE II.

City .... Instructor in zoology ....

Upon what phases of zoology do you place special emphasis? ....

Amount of field work as a required part of course? ....

Upon what animals and of what character? ....

Where did you receive preparation? .... How long? .... Degree? ....

How many years' experience in teaching zoology? ....

Check off from the following list the courses which you studied in college and give the time devoted to each. Other courses not given in list may be filled in at the bottom.

General biology	Heredity ....
Invertebrate zoology (anatomy)...	Zoogeography ....
Vertebrate zoology (anatomy).....	Physiology ....
Embryology	Hygiene ....
Entomology	Laboratory methods ....
Organic evolution	Field, or natural history courses....

Do you feel that your preparation in college was of the sort which enables one to give the proper sort of high school course? .... Reasons for your answer ....

What would you suggest as the proper college training for the teacher who is to give a high school course in zoology?

Do you teach zoology (or biology) as your major subject, or as a side line? (We should like to determine how many teachers are engaged primarily for biology; there seems to be a tendency to slight the subject in this respect.)

How many periods per week (in your school) should be devoted to recitation? .... How many to laboratory work? .... How long should periods be? ....

Schools Replying to Questionnaires.

All the schools listed replied to first questionnaire.

Those schools preceded by the symbol "/" replied to the second questionnaire.

In those schools preceded by the symbol "-" no course has been offered.

The symbol "o" indicates that the course was once given but discontinued.

The number following the name of school is the school enrollment as given by the zoology teacher; where this information was not obtained, a question mark follows the name.

o Adrian, ?.
  Allegan, 250.
/ Alma, 240.
/ Alpena, 250.
/ Ann Arbor, 700.
o Bad Axe, ?.
/ Battle Creek, 930.
  Bay City, E. H. S., ?.
/ Benton Harbor, 300.
/ Bessemer, 150.
- Boyne City, ?.
/ Calumet, 1183.
- Cedar Springs, 90.
/ Cheboygan, 200.
- Chelsea, 130.
/ Coldwater, 265.
/ Colon, 75.
/ Detroit, C. H. S., 2,500.
/ Dexter, 80.
o Dowagiac, ?.
- Dundee, ?.
- Eaton Rapids, 156.
- Escanaba, 350.
/ Evart, 118.
- Fenton, 130.
/ Flint, 588.
/ Flushing, 110.
- Fremont, ?.
/ Grand Ledge, 165.
  Grand Rapids, C. H. S., 1,400.
/ Grand Rapids, U. H. S., 375.
  Harbor Beach, 76.
/ Harbor Springs, 150.
/ Hillsdale, 274.
/ Houghton, ?.
- Howell, ?.
- Ionia, 211.
/ Ishpeming, 562.
/ Jackson, 750.
/ Kalamazoo, C. H. S., 700.
/ Lake Linden, 150.
/ Lansing, 670.
o Ludington, 235.
/ Mancelona, 91.
/ Manistee, ?.
/ Manistique, 175.
- Marquette, ?.
/ Mt. Clemens, 250.
  Mt. Pleasant, 233.
/ Newberry, 150.
- Plymouth, ?.
  Shephard, 240.
- White Pigeon, ?.
/ Ypsilanti, 320.

Any investigation carried on by means of a questionnaire is

limited by the inadequacy of its method. Many weaknesses of this method are obvious, and all tend to render results uncertain. But one must be content with using the only means at his disposal, and must make the best of material thus obtained. The writer has tried to do this, avoiding inaccuracy as much as possible by considering only those points about which the data were of unquestionable character. In some cases, the incompleteness of answers may be significant. For instance, there were but few answers to the question regarding nature study in the grades, and these were noncommittal as to the value of such work in preparation for high school zoology. One might conclude that little nature study is being taught in our grade schools, and that it has no influence on the secondary school biological work of the pupil who studied nature in the grades.

Discussion of Results.

Among the fifty-four replies to Questionnaire I were seventeen from superintendents or principals who state that no courses in zoology are offered in their schools. Eight of the seventeen state that courses had been given, but were discontinued. And the other nine make replies of this character: "No course in zoology is offered." In both groups, botany is usually included in the program of studies. The reasons for discontinuing zoology are to be found in the following extracts: 1. (School enrollment, 235.) "I will say that we made a change a few years ago and put in a course in agriculture and when that was made we substituted botany for the work that had been done in zoology." 2. (School enrollment, about 250.) "In reply to your letter........I would say that we are not teaching zoology this year, having changed the course to more agriculture." In a later letter, this superintendent tells us that he believes that the changes "have been made in the attempt to make the scientific subjects more practical." 3. (School enrollment, about 75.) "Since botany has been made a full year subject, zoology has been, for the time being, crowded out." It must not be supposed that these conditions exist only in very small schools. Those which have not offered zoology are situated in towns of the following populations: 667, 1,070, 1,671, 1,764, 2,009, 2,094, 2,331, 2,338 and 5,218. The high schools which once offered zoology but have discontinued the course are located in towns of somewhat larger size, viz., 947, 1,559, 5,030, 5,088, 9,132, 10,763, 11,503 and 13,194.

What is the significance of such a widespread disfavor toward this science? The fact that botany gained a place in our school systems at an earlier date than did zoology explains in part the more frequent occurrence of botany in programs of study. Some schools complain of a lack of equipment for zoological work, but since practically everything used in teaching high school botany may be used in teaching zoology, this complaint, coming from schools which offer the former course, is not justified. We may even go to the extreme of saying that so little is absolutely necessary for fitting an elementary zoological laboratory that no school should offer this as an excuse. A demand for the work may be lacking in certain communities, but as to this we are not informed. A very important factor contributing to the disfavor in which zoology is held is the difficulty in securing teachers who can and will teach the work in addition to other subjects; and this situation is frequently met by the advice to prospective teachers that "anyone can teach zoology" or "you can read a few lessons ahead of the class." It is needless to say that the teacher who follows such advice, unless very exceptional, will do nothing to further the cause of zoology in his school. Various other elements may be effective in forcing zoology into the position of undeserved disrepute which it now occupies in some schools. But the writer believes that the most important of all factors concerned is the presentation of subject matter not adapted to the interests, needs and capabilities of high school pupils. If it be true that the course is often thus ill-adapted, should we be surprised when shown evidence that school authorities and others object to its continuance in their schools?

We have found that agiculture and botany have displaced zoology in certain schools. Are these subjects of more practical value than zoology? Yes, they are more valuable when zoology is taught in a disinterested, impersonal and academic fashion. But, emphatically, they are *not* more valuable when the teacher is willing and capable of properly presenting zoology.

In general, the time devoted to zoology is sufficient for a very fair presentation of the subject. Of thirty-six schools, thirty are giving one-semester courses, while six devote an entire year to zoology. Of the former, twenty offer a distinct one-semester course in zoology alone, and the remaining ten approximate a semester's work as included in general biology. Not all this time is devoted strictly to zoology; twenty of twenty-nine schools teach physiology in connection with zoology, while nine

schools offer separate physiology courses. Combination of these two subjects is made in one-semester courses as well as in one-year courses.

In the following table is shown the time devoted to zoology in twenty-nine schools. To facilitate comparison, the weekly allotment of time has been reduced from the several 40-, 45-, or 50-minute periods to minutes per week.

TIME DEVOTED TO ZOOLOGY IN THIRTY-FOUR SCHOOLS.

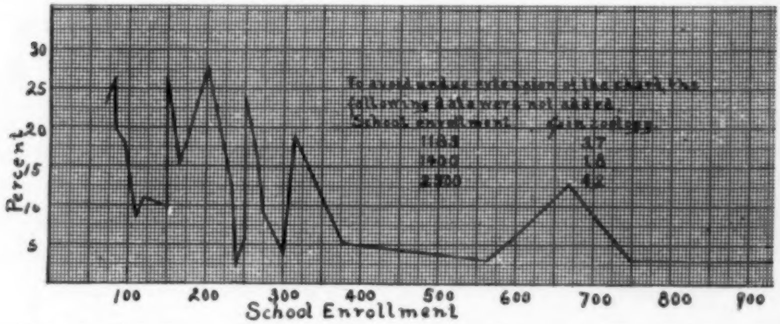
School enrollment.	Length of course in weeks.	Total time per week in minutes.	Recitation per week in minutes.	Laboratory per week in minutes.	Percentage of total time in laboratory.
150	20	200	200	0	0
110	20	225	225	0	0
274	19	225	225	0	0
90	19	225	Combined.		?
165	19	225	Combined.		?
75	20	270	225	45	16
80	19	270	225	45	16
320	20	270	225	45	16
233	20	225	180	45	20
375	20	280	200	80	28
250	20	315	225	90	28
150	20	320	200	120	37
240	40	360	225	135	37
200	20	225	135	90	40
1400	20 or 40	300	180	120	40
150	18	225	135	90	40
150	20	225	135	90	40
670	19	270	135	135	50
700	38	285	135	150	52
240	19	280	120	160	57
1183		315	135	180	57
588	22	315	135	180	57
?	20	315	135	180	57
76	20	315	135	180	57
562	18	315	135	180	57
750	40	315	135	180	57
175	13	315	135	180	57
300	20	290	120	170	58
?	20	225	90	135	60
250	20	225	90	135	60
265	18	300	112	188	63
930	40	314	112	202	64
700	19	330	110	220	66
2500	40	315	90	225	71

Double periods for laboratory work have been secured in nineteen of thirty schools; the remaining eleven schools have arranged only for single periods. There are advantages and disadvantages in both methods, but the preponderance of opinion seems to favor double periods.

In no school is zoology a required subject. The grades in which it is elected are:

Grade X	17 schools
Grade IX	8 schools
Grades X, XI	3 schools
Grades X, XI, XII	3 schools
Grades VIII, IX, X, XI, XII, and some college freshmen	1 school
Grades XI, XII	1 school

The percentage of entire school population which elects zoology is extremely variable. The figures in the accompanying list show this variation, and Chart I which is based upon them represents it graphically.



GRAPH SHOWING ELECTIONS OF ZOOLOGY IN PERCENTS OF SCHOOL ENROLLMENT. (DATA FROM 34 SCHOOLS.)

PERCENTAGE OF SCHOOL ENROLLMENT ELECTING ZOOLOGY IN THIRTY-FOUR SCHOOLS.

School enrollment.	Percentage of enrollment electing zoology.	School enrollment.	Percentage of enrollment electing zoology.
75	23	265	16
76	26.3	274	9.1
80	20	300	3.6
90	18	320	18
110	9.09	375	5
118	11	562	3
150	10	588	5.2
150	20	670	13.1
150	22	700	4.2
150	26	700	4.2
165	15	750	2.1
175	18	930	2.1
200	24	1183	3.7
233	12	1400	1.8
240	2.5	2500	4.2
240	4.12		
250	6		
250	7.2		
250	24		

What is the explanation for these violent fluctuations? In general, there is less regularity in the smaller schools, i. e., less than three hundred enrollment, while in the larger ones there is more regularity. Although no explanations for the fluctuation

can be secured from the questionnaires, some conjectures are here offered.

In large schools, the low percentages of elections, as expressed in terms of school enrollment, is probably primarily due to the larger number of elective subjects offered. Small schools usually offer fewer electives, hence zoology has less competition. It was pointed out by a certain teacher, in conversation with the writer, that the number of students in her classes is limited by the size of the laboratory and the number of recitations actually possible.

Moreover, the grade in which zoology is elected has a bearing on this question. A higher percentage for the ninth grade might be expected for several reasons, viz., there are more pupils in the ninth grade than in any other. And zoology may offer a stronger appeal to young pupils than to older ones. Again, in some schools, less choice is allowed in the elections of the first high school year. The following figures derived from thirty-three schools indicate the percentages of entire school enrollment electing zoology, arranged according to grades:

School enrollment.	Percentage of enrollment electing zoology.
GRADE IX.	
250	7.2
165	15.1
150	20
80	20
200	24
250	24
150	26
76	26.3
GRADE X.	
1400	1.8
930	2.1
240	2.5
300	3.6
240	4.1
2500	4.2
700	4.2
250	6
110	9.1
274	9.1
150	10
118	11
670	13.1
265	16
90	18
150	22
75	23
GRADES X, XI.	
1183	3.7
375	5
175	18
GRADES X, XI, XII.	
750	2.1
562	3
320	18
GRADES VIII, IX, X, XI, XII, AND SOME COLLEGE FRESHMEN.	
700	4.2
GRADES XI, XII.	
588	5.2

The fact that zoology is always elective renders operative many factors which contribute to the irregularity in elections. The first and probably most effective of these is the personality and method of the teacher. An unusually capable teacher, one who is much interested in his work, or one who is "easy," is likely to have large classes. On the other hand, the uninterested teacher, the "nagger," or the "hard" teacher, will be less popular, as is

evidenced by his small classes. It is a fact, as brought out in conversation with certain teachers, that principals and heads of departments in some schools urge pupils to elect zoology instead of other subjects, or they may guide pupils away from zoology. It is probable that to some students other subjects are more attractive in subject matter or presentation, and their elections are made accordingly. Community feeling may not favor zoology on the ground that it is of little or no value to the pupil, and parents may advise their children to avoid the subject. Numerous other factors within the school may be responsible, but these are believed to be most important.

Textbooks are of prime importance in determining the character of any course. For this reason, and for the benefit of teachers interested in texts, a list of those used in thirty-eight schools is here introduced.

Linville and Kelly, seven schools, four one-semester courses; three one-year courses.
Jordan, Kellogg and Heath, six schools, four one-semester courses; two one-year courses.
Hunter (*Essentials of Biology*), six schools, all one-semester courses.
Jordan and Kellogg, four schools, all one-semester courses.
Davison, four schools, all one-semester courses.
Jordan and Heath, two schools, one one-semester course; one one-year course.
Davenport, two schools, both one-semester courses.
Colton, two schools, both one-semester courses.
Kellogg (*Elementary Zoology*), one school, one-semester course.
Bigelow, one school.
Peabody and Hunt, one school, one-semester course.
Kellogg (*Animals and Man*), one school, one-year course.
Herrick, one school, one-semester course.

Several laboratory manuals are mentioned in answers to the questionnaire. Arranged in the order of most common use, they are: *Jordan and Price, Sharpe, Colton, Needham, Ellis, Meier, Linville and Kelly, Peabody,* and *Hunter and Valentine.* Of thirty-one schools, sixteen use these published manuals. In only five cases are they used without supplementary notes written by the teacher. Among these thirty-one schools, fifteen do not use any published manual, but the teacher depends entirely upon directions given by means of mimeographed sheets or blackboard outlines prepared by himself.

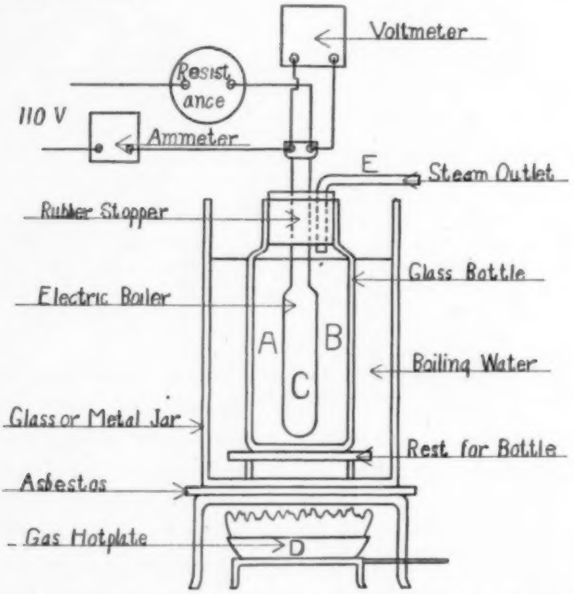
Outside reading is assigned to a considerable extent, but the nature of this, on account of incomplete answers, is so uncertain as not to warrant discussion.

(*Concluded in the January, 1917, Issue.*)

ELECTRICAL METHOD OF MEASURING HEAT OF VAPORIZATION.

By H. C. Beltz,
Salt Lake City, Utah.

This method of measuring heat of vaporization has been used in the Salt Lake Technical High School for some time, and gives very accurate results (the percentage of error is but a fraction of one per cent). When the apparatus is connected permanently as shown in the diagram, the data for the experiment can be taken in less than thirty minutes. The pupils are required to make accurate diagrams of electrical connections, paying special attention to the method of connecting the ammeter and voltmeter in the circuit.



The water in the outer vessel, B, is kept at boiling temperature by means of the gas burner, D; the water in the inner vessel, A, is boiled away by the electric heater, C, the steam escaping through E. *The temperatures on both sides of the bottle, A, are the same, and all of the electrical energy measured is used in vaporizing the water.* The weights of the bottle and water are taken before and after boiling. The exact time the appearance of the condensed steam occurs in E is recorded, and the ammeter and voltmeter read every minute, an average of these readings being used as the correct value. At the time of discontinuing

boiling, the heater, C, and the stopper, F, are quickly removed. Following are data, computations and results made by pupils.

Weight of water and bottle before boiling—650.0 g.
Weight of water and bottle after boiling—501.4 g.
Boiling started—1:20 o'clock.
Boiling stopped—1:35 o'clock.
Average of ammeter readings—4.1.
Average of voltmeter readings—90.2.
650.0—501.4 = 148.6 g. of steam produced.
$90.2 \times 4.1 = 369.8$ watts.
369.8×900 sec. = 332,820 watt-seconds.
.24 cal. = 1 watt-sec. (from hand book).
$332{,}820 \times .24 = 79{,}876.8$ cal. used in making 148.6 g. of steam.
$79{,}876.8 \div 148.6 = 537.3$ cal. used in making 1 g. of steam.

Every high school that gives a course in physics should possess a standard ammeter and voltmeter. The only additional apparatus to the regular equipment needed for this experiment is an electric boiler, "El Boilo," which is sold at nearly every electrical supply store for approximately $2.50. The same apparatus can be used equally well for determining the electrical equivalent of heat.

THE DETERMINATION OF ELECTRICAL RESISTANCES BY MEANS OF POTENTIAL DIFFERENCES.

By R. A. Burtnett,
Champaign, Ill., High School.

The method herewith presented for the determination of electrical resistance offers a deviation from that which is usually used in secondary laboratories—the Wheatstone's bridge method. By the use of the same galvanometer and equally accurate resistance boxes, equally accurate results may be obtained.

With reference to Figure 1, the set-up consists of a crowfoot cell connected in series with a resistance box, R, a very high resistance, Z (perhaps one myriaohm, depending upon voltage of cell), and the unknown resistance, X. The galvanometer is connected to middle points of the double-pole, double-throw switch. With the switch in positions *a* and *b*, the galvanometer is connected across the terminals of the resistance box and unknown resistance respectively. The object of the resistance, Z, is, of course, to prevent the polarization of the cell. The size of this resistance may vary three hundred per cent from the amount suggested above, in accordance with the strength and type of the cell used. The crowfoot with copper sulphate solution is recommended, however, on account of its well-known nonpolarizing

qualities. The error introduced by polarization may be materially reduced by inserting a tapping key in the primary circuit. With the tapping key closed—if used—and the double switch in position *b,* the galvanometer will deflect owing to a P. D. between its terminals equal to the potential drop through the unknown resistance, X. The current through the galvanometer (designated by I_{g1}) is, from Ohm's law, equal to the drop of potential through X (designated by E_X), divided by the resistance of the galvanometer. Or, mathematically,

$$I_{g1} = E_X / R_g. \qquad (1)$$

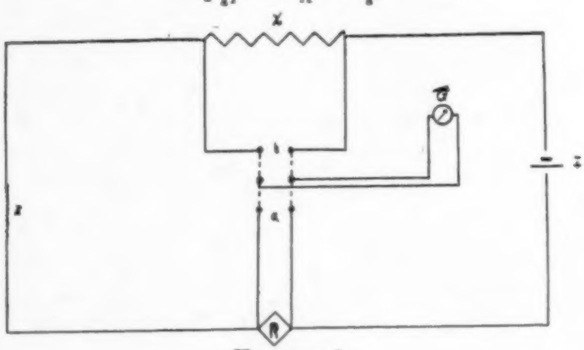


FIGURE 1.

wherein R_g is the resistance of the galvanometer. This is the equation for the current through the first derived circuit. When the switch is thrown in position *a,* there is a deflection of the galvanometer, and

$$I_{g2} = E_R / R_g. \qquad (2)$$

Dividing (1) by (2), we have

$$I_{g1} / I_{g2} = E_X / E_R. \qquad (3)$$

The voltage drops, E_X and E_R, are proportional to their resistances, R and X, or

$$E_X = KX \qquad (4)$$

and

$$E_R = KR. \qquad (4)$$

Substituting in (3),

$$I_{g1}/I_{g2} = KX / KR = X / R. \qquad (5)$$

But the current through the galvanometer is proportional to the galvanometer deflections.

Hence,

$$I_{g1} = Kd_1 = Kd_X \qquad (6)$$

and

$$I_{g2} = Kd_2 = Kd_R \qquad (6)$$

wherein d stands for the deflections in scale divisions.

Substituting in (5),

$$Kd_X / Kd_R = X/R \qquad (7)$$

or

$$X = Rd_X/d_R \qquad (8)$$

If R (from the resistance box of known values of resistances) is in ohms, then in equation (8) X is in ohms provided d_X and d_R are in any other units of the same size.

It is well in manipulation to choose and vary R so that $d_X = d_R$ as nearly as possible. If this relation holds, then from (8)

$$d_X/d_R = 1$$

and

$$X = R.$$

Obviously, this condition introduces the minimum error. The higher the value of X, the higher, necessarily, is the value of R which must be chosen by adjusting the plugs in the resistance box for each unknown resistance being measured. If a very large X is being measured, it may be necessary to reduce Z by two hundred per cent inasmuch as R is correspondingly increased with X. Care should be taken to shunt galvanometer if large resistance is being measured.

Resistance No.	Z_w	d_x	d_R	R_w	X_w	Check
1	2,400	21.1	22.1	4	3.81	
2	9,000	22.6	24.0	14	13.18	16.99
1 and 2 in series	10,700	24.15	21.85	15	16.52	16.52

Mean value—16.755 w. Per cent Diff. from Mean—1.25.

If conditions are such that d_X is approximately equal to d_R, then aside from a very small error due to polarization which may be almost entirely eliminated by rapid and accurate manipulation, the per cent error in the result is the same as that of the resistance box which is. of course, accepted as standard.

To give an idea of the accuracy and the applicability of the method, a table of data collected by the writer is given above. The manipulation is very simple and may well be intrusted to junior and senior high school students.

REPORT ON TALC AND SOAPSTONE.

The Geological Survey now has available for distribution its annual statement of talc and soapstone in 1915. During the year, 186,891 short tons of talc and soapstone, valued at $1,891,582, were sold in the United States, an increase of eight per cent in quanity and one per cent in value over the amount sold in 1914.

RADIOACTIVITY IN THE HIGH SCHOOL.

By W. F. Hoyt,
Normal School, Peru, Neb.

The discovery of radioactivity by Becquerel and Crookes, and the development of the theory of atomic disintegration by the Curies, Ramsey, Soddy, J. J. Thomson, Millikan, and others, have affected vitally our conception of the nature of matter and electricity. While an atomic theory is still essential, the atom universally accepted by scientists today would hardly be recognized by Dalton as his supposed homogeneous, adamantine, indivisible particle. The electronic theory of the atom so unifies, simplifies and correlates our previous knowledge of such seemingly diverse subjects as matter and energy, electricity, chemism, elements, light, radioactivity, X-rays, etc., that its acceptance by thinking men is inescapable, and yet many texts and more teachers still hark back to the scientific bone yard for their ideas of these topics. If the electronic theory had no basis of experimentation and fact, but depended wholly upon its ability to harmonize the above, and to prophesy the future accomplishments of science as it does, it would still deserve universal acceptance.

The formulation and explanation of this theory are still considered so abstruse, and the demonstration of its existence and effects so far beyond ordinary high school equipment, that many teachers refer casually to it as an interesting deduction from some mysterious operations by expert specialists, or ignore it altogether. The purpose of this paper is to show that a brief study and simple demonstration of radioactivity is not beyond the ordinary laboratory equipment. The necessary apparatus consists only of a simple static machine or induction coil, a Geissler tube, a photographic plate, and a spinthariscope All but the last named are found in every moderately equipped laboratory, or may be obtained in any town, and the spinthariscope itself is found in many schools I shall consider this inexpensive instrument first as the basis of three rather striking experiments In its common form, it resembles the eyepiece of a microscope, except that the distal lens is replaced by a metallic base which has glued on its inner surface a fluorescent substance such as zinc sulphide. Just over the base with its fluorescent screen is placed a watch hand which holds a tiny bit of some radium salt. This hand should be movable so that it may be swung clear of the base when the latter is unscrewed from the eyepiece.

The following very suggestive experiments may be performed with this apparatus:

First.—If the student is taken into a dark room for several minutes, or if the demonstration is given at night even in the presence of artificial light, he will be enabled to see the wonderful flashes of light resembling shooting stars, when the ions from the disintegrating atoms of radium strike the zinc sulphide screen. If you are so fortunate as to have one of the older spinthariscopes which have rather more of the radium salt, you will see a pulsating nebula of light surrounded with flashing meteors. This gives a good demonstration of the constant shower of electrons from radioactive substances, without sensible loss of weight and power.

Second.—Unscrew the base and turn the hand containing the bit of radium salt clear of the base and place it over metallic or other opaque objects lying on the plate-holding envelope next to the sensitive surface of a plate, and leave for from a half day to two or more days. As far as I have been able to experiment, the radiograph increases in clarity with the time of exposure up to at least two days with the instrument in our laboratory. Each

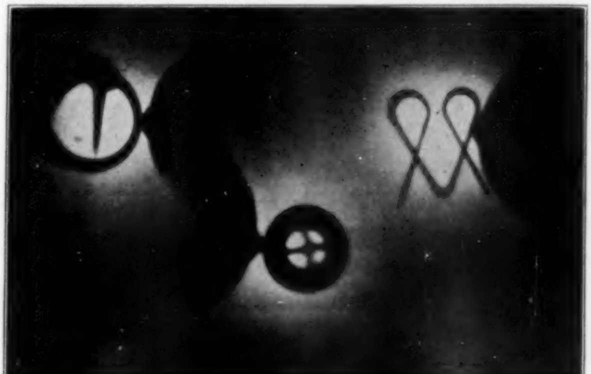


FIGURE 1.

object must be exposed separately. The first radiograph taken (Figure 1) was of a button, a paper clip, and a ring surrounding a carpet tack, and was exposed about eighteen hours for each object. The next radiograph taken (Figure 2) was that of the letters spelling RADIUM. These letters were cut out of thin copper sheeting and pasted on the envelope. Note that the gamma rays began to penetrate the copper directly under the bit of radium salt, but not at an angle. A comparison of these radio-

graphs with X-ray photographs show the similarity or identity of the gamma rays and the so-called Roentgen rays.

Third.—Bring the base within from two to six inches of a charged electroscope and note that the leaves slowly collapse. The student is likely to attribute this to the neutralizing effect of the electrons, rather than the ionization of the air. By changing the electric charge, and noting that the electroscope is discharged equally well whether the initial charge is positive or negative, he may be led to correct his own faulty inference.

FIGURE 2.

Salts of uranium are also radioactive and cheap, being priced at from $0.45 to $0.75 per ounce. I glued some uranium acetate that happened to be in the storeroom on a piece of cardboard, and turned it face down over a metallic U placed on a plate-holding envelope as before, and left it so exposed two days. The U was faintly impressed upon the plate, but the latter was not well developed. Evidently, a longer exposure is needed.

Fairly good radiographs or skiagraphs may be prepared by the use of a Geissler tube instead of a Crookes tube, but the exposure should be from five to ten minutes or more, depending upon the voltage of the exciting instrument. I prepared a fairly good plate with a five-minute exposure, but spoiled the plate by clumsy handling in developing. I have not succeeded very well in getting clear-cut radiographs from the discharge of a static machine in the air over a plate, but I am convinced it is possible. I did get one faint impression of an opaque object on the plate, as well as that of the printed letters on the envelope, but have not repeated the test. Beautiful results are said to have been obtained by others of electric discharges from static machines.

A very simple experiment showing the production of ions in so ordinary a chemical reaction as combustion may be performed by holding a lighted candle between the poles of a static ma-

chine, separated just far enough to prevent a discharge between them. The flame is spread out in the direction of the poles, and one part of the flame is evidently attracted by one pole, and another part by the other pole.

There is nothing very remarkable in any of the above experiments, but they illustrate fairly well many of the phenomena attending radioactivity. If I have shown that these facts and principles need not be considered a sealed book to the moderately equipped high school, the purpose of this paper will have been accomplished.

VIBRATION FREQUENCY WITH A MOTOR ROTATOR.

By M. L. Fluckey,

Lincoln High School, Los Angeles.

Many may not have tried this simple experiment, which in our laborator ygave as good results as those obtained from the ordinary vibrograph, and is equally obvious.

A motor rotator with a siren disc attached was timed, a minute at a time, for several minutes, and was found to be quite constant in speed. A cyclometer on the instrument gave the number of revolutions, but a separate speed indicator might be substituted. As an example, 1,000 revolutions took 83.3 seconds. The sound was produced by a jet of air against a 48-hole circle on the siren, giving 576.2 vibrations per second for the sound.

This sound was found to be in unison with 27.1 cm. of wire on a somometeer. The law of lengths and pitches being assumed, or worked out if desired, the length of wire corresponding to any frequency may be computed easily, or the frequency of any sound computed. A C_2 fork gave ea length of 29.8 cm., corresponding to 524 vibrations, instead of a rated 512. This was about the average of accuracy.

The same fork was also tested for wave length by the usual resonance method. The wave length at 20°C. was found to be 70.4 cm. Multiplying by the frequency of the fork, either observed or rated, gave a resulting velocity for sound a little in excess of the usual valuee given for that temperature. We were especially interested in this latter fact, as measurements taken here by different classes, at different times of year and by totally different methods—using echoes, gunshots, etc.—have given, invariably, results too large, though we tried to eliminate personal errors, and checked watches, tested distances by transits, etc. Does a sound hesitate in California?

THE ANGULAR MOMENTUM LAWS.

By Will C. Baker,
Queen's University, Kingston, Ont.

Two simple experiments on angular momentum have given satisfaction in the physical laboratory of this university during the past session, and as they have not been found in any of the available textbooks or laboratory manuals, a brief description may be of interest.

I. Conservation of Angular Momentum.

The apparatus consists of a rack of steel wire (2 mm. diam.) of the form shown in Figure 1. It is braced, as indicated, with fine piano wire and carries on its outer sides two iron spheres A,A (200 grams each), that slide up and down on the wire. This is rigidly attached to an axis consisting of a stout knitting needle

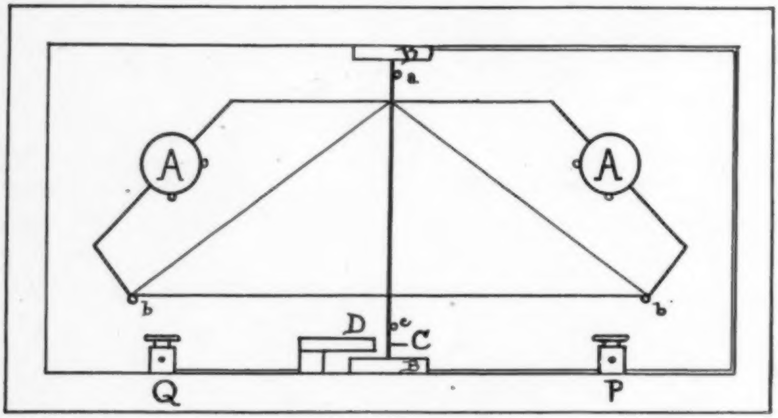


Figure 1.

that turns in holes bored partly through the brass bearing blocks, B,B. The rack also carries an arm, C, that makes electrical contact once in each revolution with the brush, D; and the whole system is held in a wooden frame (about 40 x 25 cm. internal measurement) that may be clamped to a table. Both bearing blocks are electrically connected to the binding post, P, while the brush is in connection with the post, Q. Eyelets are also provided, as shown, on the spheres and on the rack at *a, b,b, and c.* The electrical contact at D E is put in series with (1) a knife switch, (2) a dry cell, and (3) an electromagnetic stylus that records the contacts on the smoked paper of a clock-driven drum. A cotton thread running from one sphere to the other through the eyelet, *a,* holds them at the top of the frame until such time as

they are released by burning the thread. On account of the relative dimensions of the apparatus, the moment of inertia of the spheres must be calculated from the expression

$$I=2M\ (d^2+2/5r^2)$$

where d is the distance of the center of a sphere from the axis and r is its radius. The measurement of d is most easily made by taking the distance between the extreme outside points of the spheres with a pair of calipers and after subtracting the diameter of one sphere, dividing by two.

After the two spheres are tied in the upper position and the distance between their extreme points has been measured, the drum with the smoked paper is set in motion and allowed to reach full speed, the stylus tracing a straight line about it. The rack is now given a spin. As the stylus passes the join in the paper on the drum, the knife switch is closed and a record of several revolutions of the rack taken. Now when the stylus is about halfway around the drum, the thread holding the balls up is burned near the axis by means of a Bunsen flame; the spheres at once fall to the lower position and the change in angular velocity resulting from the increased moment of inertia is evident on the record. The knife switch is opened before the stylus reaches the join of the paper, so as to avoid a superposition of records.

The stylus is now raised higher on the drum and another record taken. After four or five records have been secured in this way, the apparatus is turned upside down, the thread holding the ball in position now passing through eyelets *b, c, b,* and a set of four or five records taken with the balls falling in the opposite direction. In these cases, the initial spin must not be too great or the balls will not fall quickly enough.

Next, the drum must be timed to get its period of revolution; for it has been found well worth while to have the student determine the actual rather than merely the relative angular velocities. The record is now removed and "fixed" in the usual way with a dilute alcoholic solution of rosin; and while it is drying the student is set to calculate the values of the moment of inertia of the spheres in the various positions used, also the approximate value of the moment of inertia of the rack itself. The mass of one sphere and the mass per centimetre of the wire of the rack may be given the student; or similar spheres and wire may be given him to measure. It is not found possible to tie the spheres in exactly the same position each time, so the initial moments of inertia must be calculated from measurements

taken before each trial; the final positions are of course the same in each series.

By the time that the record is dry the student has found the values of all the moments of inertia required, and has seen that that of the rack is negligible. The record is now measured, using those parts that are clearly before and after the change, so as to avoid that part *during* the fall of the spheres. The results taken from an actual record are then set out as follows (using C G S units):

I_1	I_2	w_1	w_2	$\frac{I_1 w_1}{I_2 w_2}$
1.05×10^5	2.24×10^5	46.2	21.9	0.99
1.60	2.24	34.0	25.1	0.97
1.29	2.24	38.1	22.2	0.99
1.55	9.9×10^4	34.7	53.5	1.01
1.60	9.9	30.5	49.9	0.99
1.65	9.9	49.9	77.8	1.07

Mean ratio 1.004

II. Determination of Axle Friction and Change of Angular Momentum Resulting from Angular Impulse.

The apparatus used in this experiment consists of an iron disc (mass 6 kg., radius 15 cm.) mounted, with a driving spindle, on horizontal bearings. A brake shown in Figure 2 enables the friction to be adjusted to a convenient value.

A, A, are the friction blocks controlled by the screws B, B; C is the shaft end; D the support, and E a cap to ensure that the student does not alter the friction during an experiment.

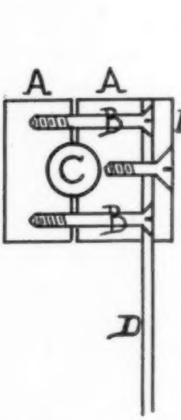


Figure 2.

The apparatus is clamped to the edge of a table so that the driving weight may have a clear fall to the floor. The end of the driving cord is looped over a peg on the spindle so that it may fall off after the weight has reached the floor and not impede the motion of the disc as it comes to rest under the frictional couple. The driving weight is slowly lowered, by turning the disc, until it just strikes the floor; and a chalk mark is put on the edge of the disc opposite a fixed index to mark this position. The weight is now raised by turning the disc through one complete revolution; and, on release, the time of fall is taken with a stop watch and the number of revolutions counted as the disc comes to rest after the weight has struck the floor. There is no

graduation on the side of the disc as the fractional turn may be estimated sufficiently accurately. Four readings are taken in this way and average values used; then another set in which the weight is raised by turning the disc through *two* complete revolutions before release, and so on. A typical set of observations are as follows:

Driving Weight. M grams.	Angle Turned Through during Fall of Weight. θ radians.	Time of Fall. Seconds.	Angle Turned Through after Weight Strikes Floor. ϕ radians.
1050	$2\pi \times 1$	2.9	$2\pi \times 2.8$
1050	$2\pi \times 3$	5.0	$2\pi \times 8.5$
1050	$2\pi \times 6$	7.2	$2\pi \times 16.7$

If K be the total couple due to frictional forces, we have, equating energies,

$$Mgh = K\theta + \tfrac{1}{2}Iw^2 + \tfrac{1}{2}Mv^2. \qquad (1)$$

where the distance fallen through by the weight is h ($h = r\theta_2$), w is the angular velocity of the disc at the instant when the weight strikes the floor, I is the moment of inertia of the disc ($=\frac{1}{2}$ mass x radius); and the velocity of impact of weight and floor is given by $v(v=rw)$. Thus we write (1) in the form

$$Mgh = K\theta + \tfrac{1}{2}w^2(I+Mr^2). \qquad (2)$$

Also considering the motion of the disc in coming to rest we have

$$\theta = w^2 - 2\frac{K}{I}\phi. \qquad (3)$$

and substituting the observed values in (2) and (3) we determine K and w. The values of K from the observations given above are:

	398 cm.-gm.-wt.
	392 cm.-gm.-wt.
	392 cm.-gm.-wt.
Mean	394 cm.-gm.-wt.

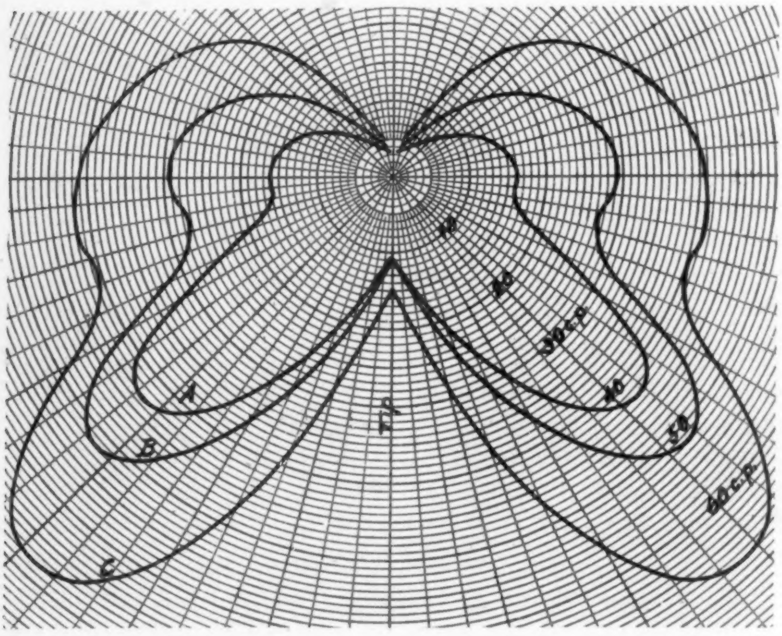
The angular impulse during the fall of the weight is given by $(Tr-K)t$, where T is the tension of the cord during the fall of the weight, r the radius of the driving spindle, and t the time of fall. As the spindle is small, the acceleration will also be small so that this impulse is given nearly enough by the expression $(Mgr-K)t$; and this should be equal to the angular momentum acquired by the disc (as it starts from rest). Using the observations quoted above, we find (using C G S units):

Angular Impulse. $(Mgr-K)t$.	Angular Momentum Acquired. Iw	Per Cent Discrepancy.
7.7×10^6	7.9×10^6	3
5.4 x	5.6 x	4
3.1 x	3.2 x	3

THE EFFECT OF DIRT ON LIGHTING FIXTURES.

By Olin D. Parsons,
Ann Arbor, Mich.

One of the most barren spots in the average high school physics text is that which has to do with photometers—barren where it might be rich in practical illustrations. An account of an experiment done in a course in "Photometry and Illumination" under Prof. H. H. Higbie at the University of Michigan may serve as an "eye opener."



Photometric Curves of Tungsten Lamp with Holophane Shade.

A. Mean Spherical c.p. 18.70. A. Lamp and Shade in Original Condition.
B. Mean Spherical c.p. 27.28. B. Lamp and Shade Cleaned with Dry Cloth.
C. Mean Spherical c.p. 38.21 C. Lamp and Shade Washed with Soap and Water.

A 60-watt tungsten lamp and a Holophane shade, both unusually dirty, were found. These were removed very carefully so as not to disturb the accumulated dust, and mounted on a photometric bench. The shade was adjusted to the same position with regard to the lamp as obtained in ordinary service. For convenience, the lamp was rotated by a motor to get average candle power values.

The candle power was determined at the tip and at 10° intervals to 160°, the limiting setting of the rotor. These values have been plotted to polar coordinates, see curve A. After this, the lamp and shade were thoroughly rubbed off with a dry, clean cloth, the ordinary method of cleaning electric fixtures, and the candle power redetermined. The results are shown by curve B. Finally, the lamp and shade were thoroughly washed with soap and water and polished. Curve C shows the results.

By methods which are described in literature listed below, we find:

C—Lamp and shade washed with soap and water—38.21 mean spherical candle power, say 100%.

B—Lamp and shade cleaned with dry cloth—27.28 mean spherical candle power, loss 28.6%.

A—Lamp and shade in original condition—18.70 mean spherical candle power, loss 51.1%.

It is easy to figure the cash loss in operating electric fixtures in such a condition. As a matter of interest, it may be said that the efficiency of the shade when clean is about 85%, or the mean spherical candle power of the bare lamp is greater than when equipped with a shade in the ratio of about 20 to 17.

The following bulletins, to be had on request, give valuable data on building illumination, particularly in its quantitative aspect:

The Lighting Handbook, Holophane Works of the General Electric Company, Cleveland, Ohio.

Bulletins: No. 7B, *Data on Illumination*; No. 13E, *Multiple Mazda Lamps*; and No. 23, *Mazda Lamps for Projection Purposes*; National Lamp Works of the General Electric Company, Nela Park, Cleveland, Ohio.

The Lighting Dictionary, and *Incandescent Lamp Data Book,* Westinghouse Lamp Company, 1261 Broadway, New York City.

PRODUCTION OF SILICA.

The annual statement on silica in 1915 is now available for distribution by the Geological Survey. During the year, the production of silica in various forms amounted to 243,340 short tons, valued at $1,270,835.

REPORT ON FELDSPAR.

The annual statement of the Geological Survey on feldspar in 1915 is now available for distribution. During the year, 113,769 short tons of feldspar, having a market value of $629,356, were sold.

AN EXPERIMENT IN SCHOOL AND STATE COOPERATION.

By Helen A. Loomis,

Bowen High School, Chicago.

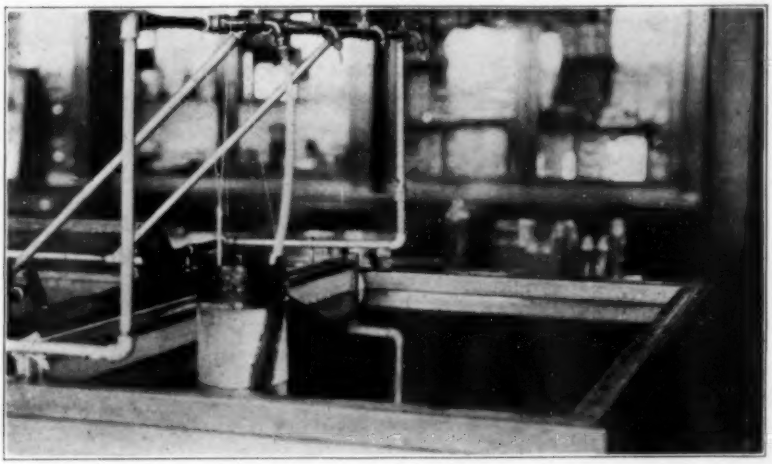
At the request of one greatly interested in science in the high schools, this article is submitted. The purpose is to present a simple illustration of the assistance awaiting our public schools through the very willing cooperation of our state institutions and business men. The experiment was worked out at the Bowen High School, Chicago, during this past year.

At the time of the Chicago Aquarium Society Exhibit, which attracted such crowds to the Art Institute, the State Fish Commission exhibited specimens of our food fishes. The zoology classes visited these exhibits, and enjoyed exceedingly the surprise of finding little fancy fishes as beautiful as birds. Unfortunately, our inland children's idea of fish is limited to bullheads, fifteen-cent goldfish, and pickled perch. The classes were given instruction on the characteristics of the living food fish, following advanced class work in the laboratory identification of preserved specimens. We then made bold enough to ask of Mr. C. B. Whitford, the State Fish Culturist, some of these specimens at the close of the exhibit, to complete our laboratory collection of twenty-five kinds. Through the kindness of Mr. Whitford and the courtesy of Mr. Meeteren, the State Commissioner, the specimens were obtained; but what is of more importance, these men became interested in our work.

The latter part of April, Mr. Whitford suggested the possibility of experimenting with a miniature hatchery in the laboratory. This tempting offer was promptly accepted, and the hatchery installed the first day of May. The state furnished the hatching jar and about 200,000 pike perch (walled-eyed pike) eggs. The jar was placed in the large goldfish tank with a trough connected at the spout. The eggs were then placed in the jar, and a current of water kept running through the pipe to the bottom, the surplus being carried off at the spout, which was covered by a bit of fine-meshed screen. Thus the eggs were kept gently but constantly rolling. The observations of the changes in the condition of the eggs, and the temperature and pressure of the water, were recorded twice daily, and specimens removed to small bottles. The water pressure was regulated to about one gallon per minute, and the temperature averaged about 48° F. Here should be acknowledged the very valuable assistance of our engineer, who saw that the water was never shut off, and of the night watchman, who kept

the pressure regulated, as too violent rolling would have ruptured the yolk sacs.

Needless to say, interest in the hatchery spread through the student body, and several faculty members, who were daily visitors, offered substantial help about the minor details of the apparatus.



In ten days, we were rewarded by seeing some of the eggs "eyed out," and on the twelfth day, with the aid of the magnifying lens, the pulsations of the heart and the turning of the embryo in the eggs could be plainly observed. On the fourteenth day, the fish began to hatch, and the process, again under magnification, was most interesting. The egg would turn over and over violently and then the transparent little fellow would squirm out, tail first, and wriggle to the surface, greatly resembling mosquito larva. The screen was removed from the spout, and soon hundreds of the little fish could be seen swimming in the tank. Fish interest ran higher. In fact, the day was devoted to demonstrating fish hatching to the visitors. During the next few nights, an interesting observation was made by the watchman, who found at daybreak the hatching was so rapid as to make the jar appear filled with a mist.

Fully two-thirds of the eggs hatched; most of the remainder proved infertile, and a few were attacked by fungus. At the end of the week, when the yolk sac was absorbed, it was necessary to supply larger quarters to prevent cannibalism. The fish were siphoned out, and transported to Wolf Lake, and so returned to state waters.

But even this does not include all our benefits. During the time of the experiment, Mr. Whitford visited us, and, happening in on the Bird Club day, gave the members a splendid talk on game birds, as well as fish culture. A little account of our experiment was published in the paper, and came to the attention of the Aquarium Club, who invited the instructor to one of their meetings to tell about the little hatchery. This, too, bore fruit, for the members of the club became interested in our boys and girls, who are now to form an auxiliary chapter—to boost an aquarium for Chicago. Moreover, we are to have an aquarium of the beautiful little fish—which we admired so much, but thought so unobtainable—the gift of these men.

MOUNTING FOR PROTECTING THERMOELEMENTS.

A mounting for protecting laboratory thermoelements from damage by contamination or by mechanical strains has been developed at the Bureau of Standards, Department of Commerce, in connection with investigations of the expansion of substances on heating. Protective mountings with convenient heads for attaching the leads to the millivolmeters that indicate the temperatures are common with industrial thermocouples; but the wires of the average couple to be seen in a physical or chemical laboratory are either entirely unprotected or else merely have portions adjacent to the junctions inserted in glass or porcelain tubes. The mounting regularly used in the expansion laboratory of the Bureau not only affords adequate protection to the thermoelement, but also adds greatly to the convenience of its use.

Scientific Paper, No. 276, entitled *Protected Thermoelements*, discusses this subject and persons interested may obtain copies, free of charge, upon request to the Bureau of Standards, Washington, D. C.

GALVANOMETER DESIGN.

Galvanometers are instruments for the detection or measurement of small electric currents or small voltages and are much used in various kinds of electrical testing. The user of such an instrument is concerned with its sensitivity, either to current or to voltages, its period, etc.; that is, he is concerned with its performance or operation constants. These necessarily depend upon the intrinsic or construction constants, which in turn depend upon the size, shape, kind of material, etc., of which the parts are made.

The relations between these two sets of constants are of interest to both the user and the maker of galvanometers. They are, however, of more importance to the maker, since they may be made to serve as a basis for predetermining values for the intrinsic constants such as will give previously selected or specified values for the operation constants. In other words, the relations in question will tell him what values the construction constants must have in order that the galvanometer may meet definite performance specifications.

These matters are discussed and illustrated by concrete examples in a paper just published by the Bureau of Standards, Department of Commerce. Copies of the paper, *Scientific Paper, No. 273*, may be had on request addressed to the Director, Bureau of Standards, Washington, D. C.

PROBLEM DEPARTMENT.

By J. O. Hassler,
Englewood High School, Chicago.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics. Besides those that are interesting per se, *some are practical, some are useful to teachers in class work, and there are occasionally some whose solutions introduce modern mathematical theories and, we hope, encourage further investigation in these directions. All readers are invited to propose problems and solve problems here proposed. Problems and solutions will be credited to their authors. In selecting solutions for publication we consider* accuracy, completeness, *and* brevity *as essential. Address all communications to J. O. Hassler, 2301 W. 110th Place, Chicago.*

Algebra.

481. *Proposed by Paul Baldwin, Evansville, Ind.*

Find the roots of the equation,

$$x^4-(x^3-1)\sqrt{x^2+44}+22x^3-x-14 = 0.$$

Solution by the Editor. (No solutions were received for this problem.)

Rationalizing the given equation, we obtain

$f(x) = 114x^4+11x^3-154x^2+7x+38 = 0.$

We find

$f(-2) \doteq 1{,}144,\quad f(-1) = -20,\quad f(0) = 38,\quad f(\tfrac{3}{4}) = -2.66,\quad f(1) = 16.$

Hence, there are four real roots of this equation.

Of the possible rational roots (from consideration of the factors of 38 and 114), $\frac{2}{3}$ satisfies the equation. We have, then,

$$f(x) = (3x-2)(38x^3+29x^2-32x-19) = 0.$$

By any one of the familiar methods of approximation, we obtain for the cubic factor the roots $x_1 = -1.118 \cdots$, $x_2 = -.514 \cdots$, $x_3 = .869$.

Of the roots x_1, x_2, x_3, and $\frac{2}{3}$, of the equation $f(x) = 0$, x_3 and $\frac{2}{3}$ satisfy the original equation. It is easily discovered, by roughly graphing the function, that there are no other real roots between -11 and 11.

Expanding the binomial $(x^2+44)^{\frac{1}{2}}$, and simplifying the result, we obtain for the original equation the form,

$$-14+\frac{22}{x}+2(11)^2\left(1-\frac{1}{x^3}\right)\left(1-\frac{2(11)}{x^2}+\frac{5(11)^2}{x^4}-\frac{14(11)^3}{x^6}\right.$$
$$\left.+\frac{2\cdot 3\cdot 7(11)^4}{x^8}-\frac{2^2\cdot 3\cdot 11(11)^5}{x^{10}}+\frac{2\cdot 13(11)^6}{x^{12}}\cdots\right) = 0.$$

For x greater than 11, or less than -11, the series above is absolutely convergent, and one easily sees that the function is always positive for such values of x. Hence, the other roots are imaginary.

Geometry.

482. *Proposed by R. S. Beardsley, Chicago, Ill.*

Prove that the dihedral angle of a regular tetrahedron is the supplement of the dihedral angle of a regular octahedron.

I. *Solution by G. H. Crandall, Culver Military Academy, Culver, Ind., and Norman Anning, Chilliwack, B. C.*

Given the regular tetrahedron ABCD. Join the mid-points O, P, R, S, V, T, of all the edges AB, BC, BD, AD, AC, CD, respectively, of the tetrahedron. These lines form a regular octahedron. The tetrahedron AOVS is similar to the given tetrahedron, therefore regular.

It is evident, from a figure, that dihedral angle P-OV-S of the regular octahedron is supplementary to dihedral angle S-OV-A of the regular tetrahedron.

II. *Solution by the Proposer.*

Using 2 as the side of a regular tetrahedron, the altitude will be $\frac{2}{3}\sqrt{6}$, and the apothem of the base will be $\frac{1}{3}\sqrt{3}$.
$\therefore$ the tangent of the dihedral angle is $2\sqrt{2}$.

Similarly, the tangent of one-half the angle of the octahedron is $\sqrt{2}$. Since

$$\tan 2A = \frac{2\tan A}{1-\tan^2 A},$$

the tangent of the angle of the octahedron is $\dfrac{2\sqrt{2}}{1-2} = -2\sqrt{2}$.

Since the angle of the tetrahedron is acute and the angle of the octahedron is obtuse, and the tangent of one is minus the tangent of the other, they are supplementary.

483. *Proposed by the Editor.*

The following method of inscribing a regular polygon of any number of sides in a given circle is described (without proof or acknowledgment of approximation) in a certain correspondence school textbook on geometrical drawing:

"Given a circle with center O and diameter AC. With A and C as centers and AC as a radius, describe short arcs intersecting at M and draw MO intersecting the circle beyond O at N. Divide AO into as many equal parts as the polygon has sides, and make OD equal to 4 of these parts. Draw MD intersecting the circle beyond D at E. NE is a side of the desired polygon." For polygons with less than 10 sides construct the polygon with twice the number of sides and join alternate vertices.

(*a*) Prove this construction correct or incorrect as applied to the dodecagon.

(*b*) Find a general formula that will show the error of construction for any number of sides.

I. *Solution by R. M. Mathews, Riverside, Cal.*

Let $\alpha = \angle DMO$, $\beta = \angle OEM$, $\theta = \angle EON$.

Now $\theta = \alpha+\beta$. Trigonometric functions of α can be determined from the right triangle DOM, and for β from the triangle MOE.

$$MO = r\sqrt{3},\ OD = \frac{4r}{n}\quad MD = \frac{r}{n}\sqrt{3n^2+16};\quad \sin\alpha = \frac{4}{\sqrt{3n^2+16}},\ \tan\alpha = \frac{4\sqrt{3}}{3n}.$$

By the law of sines, on triangle MOE,

$$\sin\beta = \frac{4\sqrt{3}}{\sqrt{3n^2+16}};\quad \therefore\ \cos\beta = \frac{\sqrt{3n^2-32}}{\sqrt{3n^2+16}},\ \tan\beta = \frac{4\sqrt{3}}{\sqrt{3n^2-32}}.$$

$$\therefore\ \tan\theta = \tan(\alpha+\beta) = \frac{4\sqrt{3}}{3}\left[\frac{n+\sqrt{3n^2-32}}{n^2-16}\right].$$

The error is $360° - \text{arc tan}\ \dfrac{4\sqrt{3}}{3}\left[\dfrac{n+\sqrt{3n^2-32}}{n^2-16}\right]$.

Computation shows that the error is zero for $n = 4$ and $n = 12$.

For $n = 5, 6, 7, 8, 8, 10$, the error ranges from $-38'$ to $-1' 24''$.
For $13 \leqq n \leqq 50$, the maximum error is $+3'$ with an average of $2'$.

Trigonometry.

484. *Proposed by W. L. Baughman, East St. Louis (Ill.) High School.*
Show that

$$\tan 18^\circ = \frac{(3\sqrt{5}-5)(\sqrt{10+2\sqrt{5}})}{20}.$$

I. *Solution by R. M. Mathews, Riverside, Cal., also (with trivial variations) by Mabel G. Burdick, Stapleton, N. Y., F. C. Gegenheimer, Marion, Ohio, and Murray J. Leventhal, New York City.*

From plane geometry, the side of a regular decagon inscribed in a circle of radius r is $\frac{r}{2}(\sqrt{5}-1)$ and its apothem is $\frac{r}{4}\sqrt{10+2\sqrt{5}}$.
Therefore,

$$\tan 18^\circ = \frac{r}{4}(\sqrt{5}-1) \div \frac{r}{4}\sqrt{10+2\sqrt{5}} = \frac{(\sqrt{5}-1)\sqrt{10+2\sqrt{5}}}{2(5+\sqrt{5})}.$$

Rationalize this denominator, and the result reduces to the required form.

II. *Solution by L. E. A. Ling, La Grange, Ill.*

$$2(18^\circ) = 90^\circ-3(18^\circ).$$
$$\therefore \sin 2(18^\circ) = \sin[90^\circ-3(18^\circ)] = \cos 3(18^\circ).$$
$$\therefore 2\sin 18^\circ \cos 18^\circ = 4\cos^3 18^\circ - 3\cos 18^\circ.$$
$$\therefore 2\sin 18^\circ = 4\cos^2 18^\circ - 3,$$
$$= 1-4\sin^2 18^\circ.$$
$$\therefore 4\sin^2 18^\circ + 2\sin 18^\circ = 1.$$

Solving,

$$\sin 18^\circ = \tfrac{1}{4}(\sqrt{5}-1). \qquad (1)$$
$$\therefore \cos 18^\circ = \sqrt{1-[\tfrac{1}{4}(\sqrt{5}-1)]^2}$$
$$= \tfrac{1}{4}\sqrt{10+2\sqrt{5}}. \qquad (2)$$
$$(1)\div(2), \quad \tan 18^\circ = (\sqrt{5}-1)\div\sqrt{10+2\sqrt{5}}$$
$$= \frac{(3\sqrt{5}-5)\sqrt{10+2\sqrt{5}}}{20}.$$

III. *Solution by Walter C. Eells, Whitman College, Walla Walla, Wash.*

From elementary trigonometry.

$$\cos 5x = 16\cos^5 x - 20\cos^3 x + 5\cos x.$$

Put $5x = 90^\circ$, whence $x = 18^\circ$, and this becomes

$$0 = 16\cos^5 18^\circ - 20\cos^3 18^\circ + 5\cos 18^\circ.$$
$$\therefore \cos^2 18^\circ = \tfrac{1}{8}(5\pm\sqrt{5}).$$

Since $\cos 18^\circ > \cos 30^\circ$, the negative value of the radical is impossible, and

$$\cos 18^\circ = \sqrt{\frac{5+\sqrt{5}}{8}} = \tfrac{1}{4}\sqrt{10+2\sqrt{5}}.$$
$$\sin 18^\circ = \sqrt{1-\cos^2 18^\circ} = \tfrac{1}{4}(\sqrt{5}-1).$$
$$\therefore \tan 18^\circ = (\sqrt{5}-1)\div\sqrt{10+2\sqrt{5}} = \frac{(3\sqrt{5}-5)\sqrt{10+2\sqrt{5}}}{20}.$$

485. *Proposed by Nelson L. Roray, Metuchen, N. J.*
If $\cos\theta+\cos\phi = a$, and $\sin\theta+\sin\phi = b$, find $\cos\theta\cos\phi$.

I. *Solution by R. M. Mathews, Mabel G. Burdick, Murray J. Leventhal, and L. E. A. Ling.*

Squaring the given equations and adding, we obtain,

$$2(\cos\theta\cos\phi+\sin\theta\sin\phi) = a^2+b^2-2.$$

$$\therefore \cos(\theta-\phi) = \tfrac{1}{2}(a^2+b^2-2).$$

Subtracting the square of the second equation from the square of the first,

$$2\cos(\theta+\phi)+\cos 2\phi+\cos 2\theta = a^2-b^2,$$

$$2\cos(\theta+\phi)+2\cos(\theta+\phi)\cos(\theta-\phi) = a^2-b^2.$$

$$\cos(\theta+\phi) = \frac{a^2-b^2}{2[1+\cos(\theta-\phi)]} = \frac{a^2-b^2}{a^2+b^2}.$$

$$\therefore \cos(\theta+\phi)+\cos(\theta-\phi) = 2\cos\theta\cos\phi = \frac{a^2-b^2}{a^2+b^2}+\frac{a^2+b^2-2}{2}.$$

$$\therefore \cos\theta\cdot\cos\phi = \frac{(a+b^2)^2-4b^2}{4(a^2+b^2)}.$$

II. *Solution by C. E. Githens, Wheeling, W. Va., and Walter C. Eells.*

Let x and y be the cosine of θ and ϕ, respectively. Then $\sqrt{1-x^2}$ and $\sqrt{1-y^2}$ represent their respective sines. We have

$$x+y = a. \qquad (1)$$

$$\sqrt{1-x^2}+\sqrt{1-y^2} = b. \qquad (2)$$

Substituting $x = a-y$ in (2), transposing and squaring to eliminate the radical, produces the quadratic equation,

$$4y^2-4ay = \frac{4b^2-(a^2+b^2)^2}{a^2+b^2},$$

whence

$$y = \tfrac{1}{2}\left(a\pm b\sqrt{\frac{4-(a^2+b^2)}{a^2+b^2}}\right),$$

$$x = \tfrac{1}{2}\left(a\mp b\sqrt{\frac{4-(a^2+b^2)}{a^2+b^2}}\right),$$

and

$$xy = \frac{(a^2+b^2)^2-4b^2}{4(a^2+b^2)} = \cos\theta\cos\phi.$$

CREDIT FOR SOLUTIONS.

482. Norman Anning, R. S. Beardsley, Mabel G. Burdick, G. H. Crandall, Frank C. Gegenheimer, R. W. Lord, R. M. Mathews. (7)

483. Norman Anning, R. M. Mathews. (2)

484. Norman Anning, Mabel G. Burdick, Walter C. Eells, Frank C. Gegenheimer, C. E. Githens, Murray J. Leventhal, L. E. A. Ling, R. W. Lord, R. T. MacGregor, R. M. Mathews, E. R. Vanderhoof. (11)

485. Norman Anning, Mabel G. Burdick, Walter C. Eells, C. E. Githens, Murray J. Leventhal, L. E. A. Ling, R. M. Mathews. (7)

27 solutions.

PROBLEMS FOR SOLUTION.

Algebra.

496. *Proposed by Felix A. Ciampi, New York City.*

Solve the simultaneous equations,

$$x^2+y^2+x+y = 1. \qquad (1)$$

$$x^4+y^4+x^3+y^3 = 1. \qquad (2)$$

497. *Proposed by Norman Anning, Chilliwack, B. C.*

Solve in positive integers,

$$x^2+y^2 = 31^2+l^2 = 32^2+m^2 = 33^2+n^2.$$

Geometry.

498. *Proposed by E. R. Vanderhoof, Denver, Col.*

Given the center and radius of a circle to find the side of the inscribed square by means of the compass alone.

499. *Proposed by R. M. Mathews, Riverside, Cal.*

Through the edges of a trihedral angle planes are passed orthogonal to the opposite faces. Prove the planes coaxial.

Trigonometry.

500. *Proposed by Nelson L. Roray, Metuchen, N. J.*

In any triangle show that

$$\frac{a^2 \sin(B-C)}{\sin B+\sin C}+\frac{b^2\sin(C-A)}{\sin C+\sin A}+\frac{c^2\sin(A-B)}{\sin A+\sin B}=0.$$

SCIENCE QUESTIONS.

BY FRANKLIN T. JONES.
University School, Cleveland, Ohio.

Readers of SCHOOL SCIENCE AND MATHEMATICS *are invited to propose questions for solution—scientific or pedagogical—and to answer questions proposed by others or by themselves. Kindly address all communications to Franklin T. Jones, University School, Cleveland, Ohio.*

Please send copies of examination questions—either your own, those of some examining body, or any list which may come to hand. They are all of interest. Many will be used in these columns.

Questions and Problems for Solution.

238. *Comments are requested on the following set of physics questions, constituting the paper set by the College Board in June,* 1916.

Is it too long? [Time allowed was two hours.]

Is it too difficult? [Should the average of instruction in good schools be the standard or the best instruction in the best schools?]

Please supply solutions to questions numbered 239, 240, *and* 241.

Board Physics, June, 1916.

A teacher's certificate covering the laboratory instruction must be presented as part of the examination.

Answer ten questions as indicated below. No extra credit will be given for more than ten questions.

GROUP I. (OMIT ONE QUESTION FROM THIS GROUP.)

1. Define density and specific gravity. How do they compare in value in the metric system? How do they compare in value in the English system?

2. Upon a table stands a closed cubical box, measuring 15 cm. on each inside edge, above the top of which projects a tube 20 cm. high and 1 sq. cm. in area of inside cross section. The box and tube weigh 200 gms. Both box and tube are filled with water. Find:

(*a*) The total force exerted upon the table.

(*b*) The total force exerted by the water upon the bottom of the box.

239. When supplied with 100 cubic feet of water per second, at a head of 45 feet, what horse power is developed by a turbine water wheel having an efficiency of 80 per cent? (One cubic foot of water weighs 62.4 pounds.)

4. A trolley car starting from rest experiences a uniform acceleration. At the end of 20 seconds its speed is 15 miles per hour.
(*a*) What is its acceleration?
(*b*) How far has it traveled?

GROUP II. (OMIT ONE QUESTION FROM THIS GROUP.)

5. Given a gun, a stop watch, and a thermometer, how could the width of a lake be determined? Show how the calculations should be performed.

6. If two musical tones, one of 68 vibrations per second and the other of 70 vibrations per second, are sounded at the same time, describe and explain the effects produced. What name is given to this phenomenon?

GROUP III. (OMIT ONE QUESTION FROM THIS GROUP.)

7. Describe an experiment, preferably one which you have personally performed, by which the heat changes occuring during a change of state, such as from a liquid to a solid, may be shown. Explain the results obtained.

240. A steel projectile is moving with a speed of 700 meters per second at the instant that it strikes a target. Assuming that all of the energy of motion is transformed into heat in the projectile, calculate its rise of temperature. Take the specific heat of steel at 0.12 and the mechanical equivalent of heat at 41,800,000 ergs.

9. The air in an automobile tire has a pressure of 80 pounds per square inch at a temperature of 15° C. If, after the car has been driven, the temperature of the air in the tire has risen to 32°C., what is the air pressure in the tire?

GROUP IV. (OMIT ONE QUESTION FROM THIS GROUP.)

10. Show, by means of a diagram, the least height of a vertical plane mirror which would enable a man 6 ft. tall to see a full length image of himself.

Why does a shallow pond, when viewed from one side, appear to be less deep than it really is?

241. If the illumination necessary for reading is 2 foot candles, how far away from a reader may a 16 candle-power lamp be placed? (One foot candle is defined as the intensity of illumination produced by a source of light of one candle power at a distance of one foot from that source, the light falling perpendicularly.)

12. An object 6 in. long is placed 20 in. in front of a concave mirror who radius of curvature is 2 ft.
(*a*) Where, and at what distance from the mirror, is the image?
(b) What is the length of the image?

GROUP V. (OMIT ONE QUESTION FROM THIS GROUP.)

13. Why are high potential currents employed for the long distance transmission of electrical energy? Explain the use of transformers as employed on transmission circuits.

14. Given three 110-volt incandescent lamps, each requiring 0.5 ampere. Find the voltage required, the resistance of the circuit, and the current in the circuit.
(*a*) When the lamps are connected in series.
(*b*) When the lamps are connected in parallel.

15. An electric heater connected to a 110-volt circuit takes 600 watts. How many calories of heat does it develop in 10 minutes?

242. *The following examination paper was submitted by Hanor A. Webb, Memphis, Tenn. Comment upon it.*

HIGH SCHOOL EXAMINATION IN CHEMISTRY, STATE OF TENNESSEE, MAY 31, 1915, 1:30-3:30.

Theoretical.

1. Explain the term "atomic weight." "Molecular weight." What are the atomic weights of hydrogen? oxygen? nitrogen? chlorine? sodium?

2. What are "ions"? What happens when an electric current is passed through a solution of some salt (e. g., sodium chloride)?

3. Give the characteristic properties of an acid; a base; a salt. Washing soda (sodium carbonate) is a salt—but its solution is strongly basic. Explain.

Laboratory Processes.

4. Briefly describe the laboratory preparation of hydrogen. Draw a diagram of the apparatus, and write the equation.

5. What chemicals would be required to prepare oxygen? ammonia? carbon dioxide? hydrogen sulphide? acetylene?

6. Give the chemical names and formulas of the following common substances: charcoal, lye, bluestone, copperas, muriatic acid, lime, baking soda, brimstone, oil of vitriol, table salt.

Practical Points.

7. Give the approximate amounts and functions of five normal constituents of the atmosphere.

8. What are the ingredients of ordinary gunpowder? Explain the explosive power of this mixture.

9. What substances in solution cause temporary hardness of water? permanent hardness? How may each kind of hardness be removed.

10. Give the principal uses of the following metals—copper, iron, tin, aluminum, zinc.

Solutions and Answers.

232, *From the Comprehensive Examination in Physics set by the College Entrance Examination Board, June,* 1916.

A standard life preserver made of cork, the specific gravity of which is 0.14, measures 40 in.×12 in.×2 in.; what extra weight would the life preserver support when completely immersed in sea water of specific gravity 1.03? State the principle involved in the solution of the problem. (1 cu. ft. of fresh water weighs 62.4 lbs.)

Solution by B. P. Homan, Warrensburg, Mo.

Also solved by J. P. Drake, Emporia, Kan., and Annie Cloyd, Sewickley, Pa.

$40\text{in.}\times 12\text{in.}\times 2\text{in.}=960$ cu. in.

$\frac{960}{1}\times\frac{1}{1728}\times\frac{62.4}{1}\times\frac{1.03}{1}=35.70\frac{2}{3}$ lbs., wt. of water displaced.

$\frac{960}{1}\times\frac{1}{1728}\times\frac{62.4}{1}\times\frac{.14}{1}=4.85\frac{1}{3}$ lbs., wt. of life preserver.

$35.70\frac{2}{3}-4.85\frac{1}{3}=30.85\frac{1}{3}$ lbs., extra weight the preserver would support.

Principle involved: A body immersed in a liquid is buoyed up by a force equal to the weight of the liquid displaced.

233. *From the same source as No. 232.*

What is the source of heat which melts the ice in a tightly closed refrigerator?

If it requires 3 lbs. of ice to cool a gallon of milk (8.3 lbs.) contained in a glass jar weighing 4 lbs., from 75° F. to 40° F., what is the efficiency of the refrigerator? Assume specific heat of milk to be 1.0, specific heat of glass to be 0.12, and the latent heat of melting of ice to be 147 in the units here used.

Solution by Annie Cloyd, Sewickley, Pa.

Also solved by J. P. Drake.

Heat lost=heat gained.
Milk and glass lose heat.
$(8.3)\ (75-40)\ 1+4\ (75-40)\ .12=$heat lost.
Heat gained=heat necessary to melt the ice, and then raise water resulting to 40°F.

Heat gained=3(147)+3(40—32).
∴ 307.3BTU should equal 465 BTU.

$$E = \frac{\text{Heat used to cool milk}}{\text{Heat given used to melt ice}}$$
$$= \frac{307.3}{465} = 66\%.$$

234. *Proposed and answered by William Sayles Wake, Instructor in Physics and Chemistry, Central High School, St. Louis, Mo.*

Question. Devise and explain an electrical circuit in which there is an *electromotive force* but *no potential difference.*

Answer. Given an electromagnet produced by an alternating current. Over the end of the magnet place a symmetrical copper ring. In this ring there will be an induced current produced as in the secondary of a transformer. In this case there will be an electromotive force causing the current to flow, but there will be no potential difference, for the electromotive force is induced at all points in the ring alike, and *it is used right where it is induced.* All points of the ring are at the same potential, i. e., if a galvanometer would be connected to opposite sides of the ring, no current would flow.

Communication from Annie Cloyd, Sewickley, Pa.

"I was much pleased to have you publish the College Entrance Examination questions in School Science [October, 1916]. Would you please have solutions given for the numerical parts of 1, 2, 8, 11, and 14.

"It seems to me that the questions were unusually difficult. May I ask you to give through the magazine your opinion of the questions? I feel sure that many physics teachers would be interested."

From the Comprehensive Physics Examination of the College Entrance Examination Board, June, 1916:

(*a*) What is meant by potential energy? by kinetic energy? Give examples.

(*b*) A body whose mass is 50 gm. is raised to a height of 300 cm. What is its potential energy?

(*c*) If it is allowed to fall freely, what will be its potential energy after it has fallen through a distance of 100 cm.? What is its kinetic energy at this point? What is the sum of these two energies?

(*d*) After it has fallen through the whole distance, 300 cm., what is its kinetic energy?

(*e*) What principle do the combined answers to (*b*), (*c*), and (*d*) illustrate?

Solution.

(*b*) Potential energy = mass×distance = 50×300 = 15000 gm.-cm. *Answer.*

(*c*) Energy after falling 100 cm.=50×100=5000 gm.-cm., but is kinetic. Its kinetic energy at this point is then 5000 gm.-cm., or 5000×980 ergs. *Answer.*

Its potential energy after falling 100 cm.=50(300—100)=10000 gm.-cm. *Answer.*

Total energy=5000+10000=15000 gm.-cm. *Answer.*

2. Define coefficient of friction; mechanical advantage.

A boat weighing 1,800 lbs. is to be drawn to a point above high water level along a beach which rises 3 ft. in 10 ft. Make a sketch of a six-rope block and tackle adapted to the foregoing purpose, and calculate the force required, assuming the coefficient of friction between the boat and the beach to be 0.4.

Solution.

Frictional force=1800×.4=720 lb.

Total force to be overcome, 1800+720=2520 lb.

Mechanical advantage of beach considered as an inclined plane is 10/3, then force to be applied is 3/10 of 2520=756 lb.

Assuming the six ropes mentioned to lie between the blocks, the mechanical advantage of the block and tackle is 6.

Hence, force required is $756 \div 6 = 126$ lb. *Answer.*

8. A mass of 100 kgm. falls 10 meters. All of its energy is employed in stirring 1,000 gm. of water contained in a calorimeter which weighs 150 gm. (Specific heat, 0.1) The temperature is observed to rise 2.°3 C. Calculate the mechanical equivalent of heat.

Solution.

The work done by the falling mass=1000 kgm.-meters=100,000,000 gm.-cm. Calories observed=$[1000+150\times.1]\times 2.3=2334.5$ calories. 2334.5 calories are equivalent to 1000 kgm.-meters, hence 1 calorie is equivalent to .428 kgm.-meters of work. *Answer.*

11. How does the intensity of illumination at a joint 2 ft. distance from a 32 candle power lamp compare with the intensity of illumination at a point 3 ft. distant from the same lamp? How far away from the above lamp should one's book be placed to secure an illumination upon its pages of 2 foot candles? (One foot candle is the illumination produced by a standard candle at a distance of one foot.)

Solution.

A $3^2 2 : 2^2$, or $9 : 4$ by law of inverse squares, hence, illumination at 3 ft. from the lamp is $4/9$ the illumination at 2 ft. 32 candle power at 1 foot (definition of a candle power) is equivalent to 2 candle power at a distance given by the proportion $X^2 : 1^2 = 32 : 2 = 16 : 1$, or $X=4$ ft. *Answer.*

14. If an electric flatiron takes 5.3 amperes at 110 volts, what is the resistance of the heating element? How many watts of electric power are required to operate the apparatus? How many calories of heat should it develop in 10 minutes? How much does it cost per hour to run the flatiron at 10 cents per kilowatt hour? (1 watt second = 0.24 calories.)

Solution.

Resistance is given by Ohm's Law, $C = E \div R$, or $5.3 = 110 \div R$. Then resistance $= 110 \div 5.3 = 2+$ ohms. *Ans.*

Watts = volts $\times$ amperes $= 5.3 \times 110 = 583$ watts. *Ans.*

Heat developed $= .24C^2Rt = .24 \times 5.3 \times 5.3 \times 2+ \times 10 \times 60 = 8{,}395.2$ cal. *Ans.*

Cost = rate$\times$kilowatts $= 10 \times .583 = 5.83$ cents per hour. *Ans.*

The Editor's Opinion.

The paper asks for *ten* questions out of *fifteen*. A likely candidate should be able to answer correctly one-half of all the questions, giving him 75 per cent. Probably, the average of all who took the examination fell far below that mark. The figures will be available with the report of the Secretary of the College Board.

The Editor believes that every examination paper should give the star student a chance for a perfect mark. It will be interesting to learn how many attained 100 per cent on this paper. He frankly agrees with Miss Cloyd on its difficulty.

GOLD, SILVER, ETC., IN EASTERN STATES.

The Geological Survey now has available for distribution its annual statement on gold, silver, copper, lead and zinc in the Eastern states in 1915. The total value of the output of these five metals for the year is given as $29,968,372, an increase of nearly 158 per cent over the production in 1914.

GRAPHITE PRODUCTION.

The annual statement of the Geological Survey on graphite in 1915 is now available for distribution. According to this report, 4,718 short tons of natural graphite, valued at $429,631, were sold during the year.

RESEARCH IN PHYSICS.

By Homer L. Dodge,

State University of Iowa, Representing the American Physical Society.

It is the object of this department to present to teachers of physics the results of current research. In so far as is possible, the articles and items will be nontechnical, and it is hoped that they will not only help the teacher to keep in touch with the progress of the science, but also furnish material that will be of value in the classroom. Suggestions and contributions should be sent to H. L. Dodge, Department of Physics, State University of Iowa, Iowa City, Iowa.

The Nature of White Light.

Discussions as to the real nature of white light have been very prominent during the past twenty years. Until Lord Rayleigh called attention to the subject, it had been thought that the existence of interference bands necessarily implied a very great regularity in the velocities of the luminous body producing the light. It is now held that the regularity of ordinary interference bands has nothing to do with the vibrator, but depends entirely upon certain peculiarities of the instruments used, or of the medium passed through by the light in the interval elapsing between its emission and its reception on the screen.[1]

This can be illustrated by experiments and familiar natural phenomena. A wave in a rope or long rubber tube has a definite length and velocity, and the "hump" exhibits no tendency to spread. The phenomenon, in fact, corresponds closely to that produced by a sharp tap, as of the foot on a pavement, the noise of which lasts only as long as the time originally taken to produce it. But, under certain conditions, the sound may be prolonged and modified in character, as everyone has noticed as he has approached a long flight of steps or a picket fence, when the sound of the step is reflected back as a prolonged echo, equivalent to a musical note of high pitch. This effect arises from the fact that the wave is reflected back from each step in succession, so that a series of waves return to the ear, producing a musical tone, the pitch of which depends upon the spacing of the reflecting parts. Moreover, the extent to which the note is prolonged depends solely upon the number of these parts, and not at all upon the time during which the original disturbance lasted.

The application of the analogy to light can be readily understood if a grating be considered as consisting of a number of equally spaced reflecting bands. Light reaching the grating from any source would be reflected in a regular succession of separate disturbances, the frequency of vibration of the train depending entirely upon the spacing of the bands. If the reflecting bands were sufficiently numerous, interference effects could be obtained, but these would be merely a measure of the fineness of the grating, and could tell nothing as to the nature of the original disturbance. Thus it is seen that a grating would produce light of definite wave lengths, and give a regular spectrum, even though the motion of the original source were as irregular as possible.

The explanation of the correcponding effect produced by prisms is more difficult. The principle involved is best illustrated, perhaps, by the spreading out of waves on a pond. Taking a disturbance represented

[1]Sir J. J. Thomson, in a course of lectures on "Radiations from Atoms and Electrons" at the Royal Institution, set forth the considerations involved in such a view with remarkable lucidity. This article is a brief summary of a part of the first lecture, which was printed in full in *Engineering*, 101, 259, 1916, and the *Scientific American Supplement*, 81, 290, 1916.

by the heaping up of the water into a single hump, Lord Kelvin has worked out the theory of such disturbances, and calculated the form of the water surface after the lapse of different intervals of time. The results show that, as time goes on, the disturbance takes on more and more the ordinary wave form, the original isolated hump being replaced by a regular series of waves. The wave-length of these waves is, moreover, greater, the farther the distance from the origin, and the total number of waves depends upon the distance traveled.

A prism, on receiving an irregular light pulse, behaves in a similar way. The irregular pulse of light is spread out by the prism into an immense series of perfectly regular waves, the number of which depends on the distance traveled in the prism, and has little to do with any regularity in the vibration in which the pulse originated.

The easiest way to consider the matter is to analyze the irregular disturbance into a series of waves by means of Fourier's theorem. Fourier has proved that any kind of disturbance whatever can be represented as a series of regular waves of different frequencies, superimposed, one on the other. This holds even when the disturbance is equivalent to a loud noise. In fact, any noise whatever could be reproduced by striking, suitably and simultaneously, a large enough series of tuning forks of different pitches. But just as the tune played by a band is heard as a tune, whatever the distance of the auditor, so the noise from the forks would be transmitted without change, the wave train of each component frequently proceeding at the same speed as the rest.

In the case of water waves, however, the series of waves into which the hump could be resolved travel at different velocities, those of longer wave length traveling faster than the others. Hence, at the front of the disturbance, resulting from the subsidence of the hump, long waves will predominate, and the shorter waves will be left behind. Possibly, if one could get far enough away, the leading waves would be strictly "monochromatic." Light waves in glass and other dispersive media are propagated in a similar manner, the velocity of the wave train depending upon the wave-length. Thus, no matter how irregular the disturbance entering the glass may be, it is sorted out by the glass into perfectly regular series of definite wave-lengths. It is evident, therefore, that the action of a prism in producing a spectrum is more fundamental in character than was usually supposed, so that the prism may be said to actually "color the light."

The prism, therefore, does much more to the light than it is usually credited with, at least in the older textbooks on optics. In these, the view expressed was that the colors existed in the incident white light, and the action of the prism was simply to disentangle them. From a purely mathematical standpoint, this view was tenable, as a light pulse (corresponding to the water hump and the noise), however sharp, can be considered as the resultant of an enormous number of simple vibrations.

Physically, however, the action of the prism is not merely to split up these colors, but to prolong the time during which the disturbance lasts, the number of definite waves produced depending, as was shown in the case of water waves, upon the length of the path. From this point of view, it can be seen that a study of light passing through a prism can give no certain indication as to the nature of the vibrator in which it originated, any more than could the light from a grating be taken as a conclusive criterion of the regularity of the source.

Estimating Distances at Sea.

An interesting application of the differing velocities of waves in different media is brought forth by a recent suggestion of a method for measuring distances at sea. It is proposed to employ simultaneously emitted "wireless" signals and aerial signals, and the simultaneous striking of a submarine bell and a bell above the surface of the sea. In each case, the time lag would be a measure of the distance from the observer to the vessel or station giving the signal. The scheme would be

of value in avoiding collisions at sea in fog or thick weather. A calculator has been devised by means of which the necessary computations can be rapidly carried out.

Temperature of the Sun.

A determination of the temperature of the sun has been made from the intensity of radiation for individual wave-lengths in its spectrum, using the observations from the Smithsonian Institution at Washington made with the spectrobolometer. The deduced absolute temperature of the solar surface is found to be on the average $7300° \pm 100°$ C.

Distance of the Sun.

The accepted value for the distance from the earth to the sun is 92,900,000 miles. At present this is considered to be correct to within 30,000 miles.

Carbon Consumption in the Electric Arc.

In the case of a very short arc, of the order of 0.1 mm., for all current strengths from 2 to 100 amps., the loss of carbon from the cathode is constant and about 3.2x10.5 gm. per coulomb. This is remarkably near the electrochemical equivalent for tetravalent carbon, and it would appear that the loss of an atom of carbon from the cathode of a very short arc is accompanied by the transfer of four electronic charges of electricity. In longer arcs, the loss of weight per coulomb increases until a nearly constant value is reached at a length of about 8 mm. The additional loss is due to combustion and evaporation.

Candle Power of the Firefly.

The West Indian firefly is much brighter than those found in the United States and England. Its light is continuously fluctuating, but may readily be seen at a distance of a quarter of a mile. The grown insect measures about 30 mm. in length, by 9 mm. in breadth. The system of lights is quite unlike that of the northern specimen, and consists of a green light on either shoulder, with a bright orange light under the abdomen, the latter being visible only when the insect is in flight.

It is commonly believed that the light of the firefly is produced without heat, but when specimens of this fly are enclosed under glass, a distinct rise of temperature can be observed. The brightness of the fly has been determined by comparison with known stars in the field of vision. Its light is approximately equal to that of a star of the first magnitude, and would therefore be about 0.004 candle power.

The Atomic Weight of Hydrogen.

As a result of measurements of the ratio of the combining volumes of hydrogen and oxygen, the value 1.00772 is obtained for the atomic weight of hydrogen. This is very nearly the arithmetic mean of the results of Morley and of Noyes. The true value is concluded to be very close to 1.0077.

Radium from Carnotite Ores.

At the present time, the carnotite ores of southwestern Colorado and eastern Utah constitute the principal source of radium in the United States. The carnotites consist of a sandstone with a clay binder variably impregnated with the mineral carnotite, a hydrous potassium uranium vanadate containing Ba and Ca. By boiling carnotite ores with concentrated $H_2 SO_4$, the Ba and Ra compounds present are converted into bisulphates, which remain in solution in an excess of the acid, and may then be separated from the insoluble compounds by filtration, followed by washing the residue with concentrated $H_2 SO_4$. From the acid liquors thus obtained, the Ra is recovered by diluting with water, whereby barium-radium sulphate is precipitated.

ARTICLES IN CURRENT PERIODICALS.

American Forestry, for October; *Washington, D. C.; $3.00 per year, 25 cents a copy*: "The Bald Cypress—Identification and Characteristics" (six ill.), Samuel B. Detwiler; "Fighting A Forest Fire" (one ill.), James Brown; "War Consuming Britain's Forests" (eight ill.); "Deserts Due to Deforestation" (nine ill.), Moye Wicks; "War-Time Uses of Forest Products," A. W. Schorger; "Western Public Lands and National Forests," H. H. Chapman; "Ornamental and Shade Trees—The Tree Census," J. J. Levison.

American Journal of Botany, for October; *Brooklyn Botanic Garden, Brooklyn, N. Y.; $4.00 per year, 50 cents a copy*: "The Angular Micrometer and Its Use in Delicate and Accurate Microscopic Measurements," Howard E. Pulling; "Influence of the Medium upon the Orientation of Secondary Terrestrial Roots," Richard M. Holman; "The Anatomy and Phylogenetic Position of the Betulaceæ," Carl S. Hoar; "The Toxicity of Bog Water," George B. Rigg; "On the Osmotic Pressure of the Tissue Fluids of Jamaican Loranthaceæ Parasitic on Various Hosts," J. Arthur Harris and John V. Lawrence; "Four-Lobed Spore Mother Cells in Catharinea," Charles E. Allen; "The Wandering Tapetal Nuclei of Arisæma," F. L. Pickett; "Two Types of Variable Pubescence in Plants." P. L. Ricker; "The Seaweeds of Hawaii," Vaughan MacCaughey.

American Mathematical Monthly, for October; *5465 Greenwood Ave., Chicago; $2.00 per year*: "First Summer Meeting of the Association—Report of the Committee on Mathematical Requirements; Report of the Committee on Bureau of Information;" "Use of Transcendental Equations in Analytic Geometry," W. R. Longley; "A Differentiating Machine," Armin Elmondorf; "Relations between the Association and the Society," T. S. Fiske.

American Naturalist, for November; *Garrison, N. Y.; $4.00 per year, 40 cents a copy*:"The Evolutionary Significance of the Osmotic Pressure of the Blood," George G. Scott; "The Genetic Behavior of Mice of the Color Varieties 'Black and Tan' and 'Red,'" L. C. Dunn; "Statistical Weighing for Age of Advanced Registry Cows," C. W. Holdaway.

Educational Psychology, for September; *Baltimore, Md.; $2.50 per year, 30 cents a copy*:"Mental Tests and College Freshmen," J. C. Bell; "The Standardization of Certain Mental Tests for Ten-Year-Old Children," Homer W. Anderson and George H. Hilliard; "A Study of Physical Growth and School Standing of Boys," S. F. Stewart.

Geographical Review, for October; *Broadway at 156th St., New York City; $5.00 per year, 50 cents a copy*: "World-Wide Changes of Temperture," Charles F. Brooks; "South American Timber Resources and Their Relation to the World's Timber Supply." (one map), Raphael Zon; "The Mission Range, Montana" (one map, thirteen diagrs., seven photos), W. M. Davis; "Studies in Economic Geography" (one map, one diagr.), Charles Redway Dryer.

Journal of Geography, for November; *Madison, Wis.; $1.00 per year, 15 cents a copy*: "Economic Aspects of Inland Water Transportation," H. G. Moulton; "The Weather Factor in the Great War, V; Spring and Summer of 1916." R. DeC. Ward; "High School Commercial Geography," Sumner W. Cushing; "The Filing and Presentation of Illustrated Geographical Material," Sayrs A. Garlick.

L'Enseignement Mathematiqué, for May-July; *G. E. Stechert & Com-*
"sur quelques fonctions des côtés et des angles d'un triangle," M.
pany, 151 West 25th St., New York; 15 francs per year, 2 francs a copy: Petrovitch; "Théorème sur la moyenne arithmétique de quantités positives," M. Petrovitch; "Les théorèmes de H. A. Schwarz et K. Pohlke. Démonstrations analytiques," M. Fr. Daniëls; "Sur la courbure géodésique des lignes tracées sur la sphère." C. Cailler; "Sur l'arithmetique des nombres hypercomplexes," L. G. Du Pasquier;" Cinquante constructions géométriques du centre de courbure d'une conique à centre," F. Balitrand.

Nature-Study Review, for October; *Ithaca, N. Y.; $1.00 per year, 15 cents a copy*: "Principles Underlying Organization of Course in Nature-Study," Gilbert H. Trafton; "Humane Treatment of Animals in Zoological Gardens," R. W. Shufeldt; "Nature-Study in the Kindergarten—The Beech Tree," Cleora M. De Coster; "An Indoor Garden," Elizabeth D. Wuist.

Photo-Era, for October; *Boston, Mass.; $1.50 per year, 15 cents a copy*: "The Magic Masks (Concluded)," Milton M. Bitter; "Trees in Composition," H. L. Gleason; "Mistakes in Tank-Development and their Avoidance;" "A Measure for Depth of Focus," George S. Pfeiffer.

Physical Review, for October; *Ithaca, N. Y., $6.00 per year, 60 cents a copy*: "The Absorption Coefficients of Soft X-Rays," C. D. Miller; "Direct Current Corona from Different Surfaces and Metals," Sylvan J. Crooker; "The Fluorescence and Absorption of Certain Pleochroic Crystals of the Uranyl Salts," Edward L. Nichols and H. L. Howes; "The Mean Free Path of an Electron in a Gas and its Minimum Ionizing Potential," Karl T. Compton; "The Reflection Coefficients of Metals for the Polarized Components of Light," R. B. Wilsey; "The Carbino Effect in Various Conductors, Measured by the Electromagnetic Torque Produced," Keith K. Smith; "Application of the Electron Theory of Gaseous Dielectrics to the Calculation of Minimum Ionizing Potentials," Karl T. Compton; "Resistance and Reactance of Massed Rectangular Conductors," A. Press.

Popular Astronomy, for November; *Northfield, Minn.; $3.50 per year, 35 cents a copy*: "The Semi-Centennial of the Dearborn Observatory (Concluded);" "Dark Nebulæ," Russell Sullivan; "The History of the Discovery of the Solar Spots (Concluded)," Walter M. Mitchell; "A New Determination of the Nature of the Rotation of Venus (with Plate XXXVII)." David H. Wilson; "The Aristillus Test for the Quality of the Seeing," William H. Pickering.

School World, for October; *Macmillan & Company, London, Eng.: 7S. 6d per year*: "The Value of a Training in Science in Industrial Work,' E. F. Armstrong; "The Government Committee on Science in Secondary Education," E. H. Tripp.

Scientific Monthly, for November; *Garrison, N. Y.; $3.00 per year, 30 cents a copy*: "Explosion Craters," N. H. Darton; "The Relation of Malaria to Crop Production," D. L. Van Dine; "Stephen Hales, the Pioneer in the Hygiene of Ventilation," Dr. D. Fraser Harris; "The Place of Description, Definition, and Classification in Philosophical Biology," Prof. William E. Ritter; "The Origin and Evolution of Life upon the Earth," Dr. Henry Fairfield Osborn.

Zeitschrift für Matematischen und Naturwiscenschaftlichen Unterricht Aller Schulgattungen, 4 Heft.; *B. G. Teubner, Leipsic, Germany; 12 nos., M. 12 per year*: "Gedanken und Erfahrungen zur praktischen Ausbildung der Lehramtskandidaten für Physik," Kgl. Landesschulinspektor Dr. Karl Rosenberg; "Zur Einführung des Logarithmus im Kleinschen Sinne," Dr. K. Rieder; "Ein Beitrag zur Erklärung der Mondphasen," Prof. Dr. W. Brunner; "Der bewegliche rechte Winkel bei der Lösung von Kubischen Gleichungen.—Eine einfache Koustruktion des regulären Siebenecks," Färber; "Pythagoreische Zahlen und ein Satz über Kubische Zahlen," H. Schotten.

A SIMPLE APPARATUS FOR PHOTOSYNTHESIS.

By H. A. Webb,

West Tennessee State Normal, Memphis, Tenn.

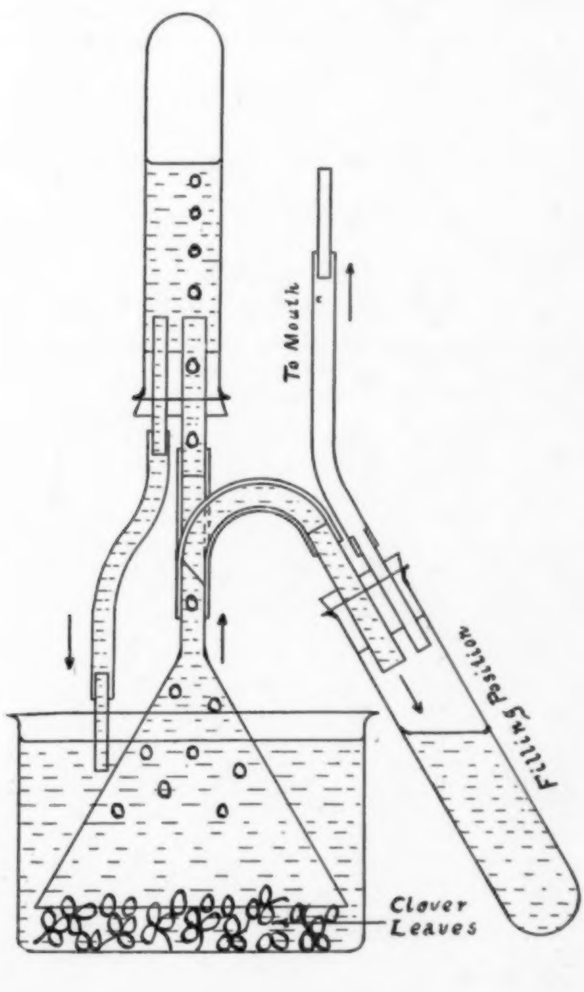
In those texts or manuals which describe an experiement on photosynthesis, we are directed to invert a test tube and funnel over some green leaves in a beaker, the entire apparatus being filled with water

saturated with carbon dioxide. Upon being placed in the sunlight, "several cubic centimeters of oxygen will soon be collected."

In my hands, this simple apparatus usually refuses to work. I have never seen anyone else obtain uniformly satisfactory results. In a recent manual, this difficulty is recognized, and we are instructed to "use no funnel smaller than six inches," but this is inconveniently large, and is but little more efficient.

A slight modification of the apparatus, as illustrated herewith, is advantageous in two ways: (1) The entire apparatus is easily filled with the carbonated water by mouth suction; and (2) the bubbles of oxygen rise rapidly to the top of the tube, their movement being unhindered by the downward current of displaced water, as this returns to the beaker by the small tube.

The illustration shows two positions—filling and collecting.



AMERICAN "ICHTHYOL."

The current publication of the United States Geological Survey, Department of the Interior, on the production of asphalt and related bitumens in 1915 contains a brief note on the subject of ichthyol. Prior to August, 1914, this asphaltic material, which is employed as an antiseptic medicament, was imported from Europe. It is derived from a bituminous rock, filled with fossil fish, that is found in the Austrian Tyrol. American imports had increased from 24,000 pounds in 1910 to 60,000 pounds in 1914, but dropped off last year to less than 25,000 pounds. In view of the inadequacy of the foreign supply to meet the domestic demand under present conditions, it is interesting to know that in this product, as in others, America has come to depend on its own resources. So far as known, there are in the United States no deposits of asphaltic material of the peculiar type from which ichthyol is derived, but American chemists have solved the problem of supplying the domestic needs in this regard, and favorably recommended substitutes for ichthyol, prepared from domestic materials by synthetic methods, are now available in the markets.

The Geological Survey's general report on *Asphalt, Related Bitumens and Bituminous Rock in 1915* is now ready for distribution. During the year, the natural asphalt of all varieties sold at the sources of production in the United States aggregated 75,751 short tons, valued at $526,490.

LIVE CHEMISTRY.

Exercise.................... Date....................

By Earl Eastman,
Atlantic City High School.

Object.—To determine the per cent of fat in cream from city dairies.

Material.—Cream from different city dairies, centrifuge, conc. sulphuric acid of specific gravity between 1.82 and 1.83.

Methods and Results.—1. (a) Carefully balance a cream bottle (be sure your initials are on it in the proper place) on a cream scale and then place a 9-gram weight on the scale pan. Then, using a pipette, transfer into the cream bottle sufficient of the well-mixed cream to exactly balance the 9-gram weight. If too much cream flows into the bottle, pour some of it out and try again. After you have weighed 9 grams of cream into the bottle, using a clean pipette, add exactly 9 ccm. of water. The remainder of the operation is exactly the same as in determining the per cent of fat in milk. Add (as previously) exactly 17.5 ccm. of conc. sulphuric acid of the proper specific gravity. Shake (when directed) with a rotary motion, and remember previous directions. Then place in the heated centrifuge and whirl for five minutes at about 200 R. P. M. Stop the machine, stand the cream bottle in boiling water, and fill the cream bottle up to the graduations on the neck with some of the boiling water. Again place in the centrifuge and whirl for two minutes. Again stand the bottle in the boiling water and fill with some of the boiling water up to the top of the graduations on the neck. Again place in the centrifuge, whirl for two minutes, remove the cream bottle, and, using a pair of dividers, determine the length of the fat column in the graduated neck (recall previous directions). The per cent of fat in the sample of cream tested will be twice the length of the fat column. Why? Now, thoroughly wash the cream bottle, using plenty of water. (b) Repeat (a) in all respects, using the same dairy cream.

2. If time permits, repeat question No. 1 in all respects, both (a) and (b), using cream from other dairies.

Conclusions.—A. Tabulate your results in a tabulation as follows:

Question	Dairy	Length of Fat Column	Per cent of Fat in the Cream	Average per cent of Fat in Cream
1.		a............	a............	
		b............	b............	
2.		a............	a............	
		b............	b............	

B. The New Jersey standard for milk fats in cream is sixteen per cent. The U. S. Standard is eighteen per cent. How do the samples which you tested compare with the N. J. standard? The United States standard?

C. How is cream formed? What is whipped cream?

COMPRESSIVE STRENGTH OF PORTLAND CEMENT MORTARS AND CONCRETES.

A publication has just been issued by the Bureau of Standards, department of Commerce, on the *Compressive Strength of Portland Cement Mortars and Concretes,* which will be of interest to contractors and engineers and, in fact, to all users of cement.

Concrete differs from most structural materials in that it is not manufactured at a mill or plant according to chemical formula, under the observation of skilled specialists, subject to rigid inspection and test and such control as to produce a uniformly homogeneous product; nor is the process of manufacture completed in a few hours or days as in the case of steel products. Furthermore, concrete is made from materials obtained from sources differing widely in characteristics which affect its quality. The proportions of the ingredients, the amount of water used in mixing, the thoroughness of mixing, the manner of placing, the atmospheric temperature and humidity, exposure to sun, rain, and wind, immersion in fresh water, sea water, or other natural solutions, all affect the quality of the concrete.

All these matters are discussed in the Bureau's publication which contains the results of some 20,000 tests. The general effect of variation in the methods of preparing the concrete is shown, and suggestions are given as to the proper methods to follow in order to obtain the best quality of concrete.

Many users of cement believe that the strength of concrete is entirely dependent upon the quantity of cement used in the mixture. This is not true, as a mixture lean in cement but properly made may have much greater strength than a rich mixture improperly prepared.

While there are not a great many failures of concrete structures, the majority of those which do occur are due to careless methods of preparing and placing the concrete, or ignorance of the effect of variable treatment. Most of the concrete used in building construction work today is mixed with an excessive quantity of water which permits of economic transportation from the mixing plant to the forms by means of chutes and troughs, but this excess of water may result in reducing the strength fifty per cent or more from that which could be obtained by using a lesser quantity of water.

The paper states that certain generally accepted methods of testing aggregates and proportioning mixtures are incorrect, and suggests methods of selecting concrete aggregates, proportioning the mixture, mixing, placing, and curing.

Copies of the publication, *Technologic Paper, No. 58,* may be obtained free upon request to the Bureau of Standards, Washington, D. C.

NEW MATHEMATICAL DEVICES.

The *Scientific American Supplement* for August 5, 1916, contains a description of the cyclo-harmonograph invented by Prof. Robert E. Moritz of the University of Washington. This is an instrument for drawing in ink or pencil a great variety of mathematical curves, such as Pascal's conchoids, the nephroids, and the foliate or rose curves, sixty-three distinct species in all.

Prof. G. N. Armstrong of the Ohio Wesleyan University, Deleware, Ohio, has published a trigonometric graph paper which enables the student to draw quickly and accurately graphs of the trigonometric functions. It can be used to illustrate many trigonometric relations and to solve trigonometric equations. Samples will be sent on application.

H. E. C.

A CONVENIENT METHOD FOR FILING U. S. TOPOGRAPHIC MAPS.

By A. J. Currier,
Albion, N. Y.

Probably most teachers of physical geography have experienced more or less trouble in handling their topographic maps and keeping them properly assorted. This is the case in the smaller schools, especially where no cases are provided. In order to better preserve the maps and to keep all of the sheets of a given locality together, I adopted this simple, but hardly original, plan. I obtained a roll of the ordinary red building paper, which is generally about thirty-six inches wide. By cutting off pieces twenty inches wide, or a little more, and folding them the short way through the middle, I had folders eighteen inches by twenty inches, which is about the size of the ordinary topographic maps. I have one folder for each survey. Small labels, bearing the name of the region and the number of sheets, can be placed at some convenient corner of the folder, and all can be placed in one pile, if there are not too many. Or this information can be written on anywhere with pencil. Student and teacher can easily and quickly find the desired map.

A NEW FIRM.

From time to time, men who have been faithful servants with some firm or corporation feel that in justice to themselves they should get out and be employers instead of employees. This is the case with the new firm of Denoyer, Geppert Company. This new firm came into existence in Chicago last August, and it has for its purpose the publishing of school maps. Mr. Denoyer was for three years head of the editorial department of A. J. Nystrom & Company. He is a college man, and has been high school teacher and principal. He was for a number of years head of the department of geography at the State Normal School at LaCrosse, Wis. His peculiar ability in sensing school map needs will enable him to bring into this firm something that will make for success from the very beginning. Associated with him in this work is Mr. O. E. Geppert, who resigned from his position as advertising manager of A. J. Nystrom & Company, in order to help in this new business. The first efforts of the new company will be an entirely new series of ancient and European history wall maps, which will be edited by men of the very highest standing in this particular phase of geographical work. This Journal wishes the greatest success to crown the efforts of the new company.

THE NEW JERSEY SCIENCE TEACHERS' ASSOCIATION.

The first meeting of this Association was a very interesting and helpful gathering to all who attended, and the influence of the Association is being felt throughout the entire state. President Stearns, in addition to his address of welcome, made some remarks, in which he compared the tedious, involved, and exacting laboratory work of the present-day science teacher with the more free and, as he thought, more inspiring teaching of the time of Steele's *Fourteen Weeks in Physics and Chemistry*, etc., to the advantage of the latter, at least in certain particulars. The aim of practical chemistry, as discussed by Mr. Weed and as illustrated in his textbook *Chemistry in the Home* seemed to be to relate the instruction more simply and more directly to the life and experience of the pupil. The inspiration received at this meeting was such as to cause the members to carry with them an enthusiasm which will enter into their entire year's work.

BOOKS RECEIVED.

Educational Measurements, by Daniel Starch, University of Wisconsin. Pages vii+202. 16x24 cm. Cloth. 1916. $1.25. The Macmillan Company, New York City.

Laboratory Manual of Agricultural Chemistry, by Charles C. Hedges and William T. Bryant, Texas Agricultural Mechanical College. Pages x+94. 13x18.5 cm. Cloth. 1916. 60 cents. Ginn & Company, Boston.

Inorganic Chemistry for Colleges, by Lyman C. Newell, Boston University. Pages x+595. 13.5x19 cm. Cloth. 1916. $2.00. D. C. Heath & Company, Boston.

Introduction to Mathematics, by Robert L. Short, Technical High School, Cleveland, Ohio, and William H. Elson, former Superintendent of Schools, Cleveland, Ohio. Pages vii+40. 13x19 cm. Cloth. 1916. $1.00. D. C. Heath & Company, Boston.

Algebra Review, by Charles H. Sampson, Huntington School, Boston, Mass. Pages iv+41. 13x19 cm. Cloth. 1916. World Book Company, Yonkers-on-Hudson, New York.

A Textbook of Botany for Colleges, by William F. Ganong, Smith College. Pages ix+401. 14x20.5 cm. Cloth. 1916. $2.00. The Macmillan Company, New York City.

Number Stories, by Alhambra G. Deming, Washington School, Winona, Minn. 205 pages. 13.5x19 cm. Cloth. 1916. Beckley-Cardy Company, Chicago.

Supervision of Arithmetic, by W. A. Jessup, University of Iowa, and L. D. Coffman, University of Minnesota. Pages vii+225. 13.5x19.5 cm. Cloth. 1916. $1.10. The Macmillan Company, New York City.

United States Life Tables by James W. Glover, University of Michigan. 65 pages. 23.5x30 cm. Cloth. 75 cents. The Government Printing Office, Washington, D. C.

BOOK REVIEWS.

Trigonometric and Logarithmic Tables, by George Wentworth and David Eugene Smith. Pages v+104. 15x24 cm. Cloth. 1914. 60 cents. Ginn & Co., Boston.

This is one of the best books of logarithmic tables published—just the thing for student and teacher. It is written by authors who know how. There are several pages in the introduction, giving definitions of terms

used, with illustrations thereof. Then comes the table of common logarithms of integers from 1 to 1,000, together with the trigonometric functions. After this is a five-place mantissa of the common logarithms of integers from 1 to 1,000. Table 6 is on the logarithms of the trigonometric functions. Table 8 is devoted to the logarithms of the natural functions. This is a handy, usable book and one which all persons using logarithms should possess. C. H. S.

Educational Measurements, by Daniel Starch, University of Wisconsin. Pages vii+202. 16x24 cm. Cloth. 1916. $1.25. The Macmillan Company, New York City.

Until comparatively recently it has been impossible to measure with any degree of accuracy one's capacity for being educated or the amount of education of any type that one really possesses. In this book we find an unfolding of the methods of approach for accomplishing the measurement of education. It is interesting from cover to cover, and filled with valuable information as to the methods adopted for measuring the knowledge and attainments of pupils, especially in elementary schools. It is a book with which not only the psychologist, but the ordinary teacher should be familiar. C. H. S.

The Carnegie Foundation for the Advancement of Teaching—The Comprehensive Plan of Insurance and Annuities for College Teachers, by Henry S. Pritchett, President of the Foundation. Pages xix+67. 18.5x25 cm. Paper. 1916. Published by the Foundation, 576 Fifth Ave., New York City.

This is a valuable contribution to the literature of pensions to university and college men. The author has made a very complete study of all phases of the situation, and has presented the conditions as they now exist in this country in a very interesting and thorough manner. Every college man, whether interested or uninterested in this subject, should possess a copy of the report. C. H. S.

The Carnegie Foundation for the Advancement of Teaching—Tenth Annual Report of the President and of the Treasurer. 141 pages. 18.5x25 cm. Paper. 1915. Published by the Foundation, 576 Fifth Ave., New York City.

This is, as the title suggests, a complete report of the two chief officers of the Foundation for the year ending September 30, 1915. It gives a resume of the research and expenditures, together with a statement of the allowance granted during the year. Likewise there is a splendid report of the study and investigation of the legal education as it is pursued in the United States. The educational survey made in Vermont is reported. An interesting table, too, is given of the tuition charges in many of the foremost colleges and universities. Pension for public school-teachers is discussed at considerable length, as well as pensions given in industrial and institutional concerns. There is a summary of the teachers' pension systems. Several pages are devoted to notices and biographical sketches of noted teachers who have recently passed away. The book is an epitome of the splendid work that the institution is doing.

C. H. S.

The Book of Thrift, by T. D. McGregor. Pages xi+349. 13x19 cm. Cloth. 1916. Funk & Wagnalls Company, New York City.

Books of all descriptions are now rapidly coming from the press. The one in question is a volume that comes at a very opportune moment, when such a waste of life and property is being indulged in. From beginning to end, the book teaches every class of people how to save, and what to do with their savings. It does not exclude any class of individuals. This being the case, it is a book for the public, and one that the public ought to read, and whose suggestions and ideas should be put into active operation.

C. H. S.

Plane Geometry, by Edith Long, Department of Mathemaics, High School, Lincoln, Neb., and W. C. Brenke, Professor of Mathematics in the University of Nebraska. Pages viii+273. 13x19 cm. $1.00 postpaid. 1916. The Century Company, New York.

In this second part of *Correlated Mathematics for Secondary Schools*, the authors aim to present the subject matter in a way more suitable to beginners than is usually done in modern books. Much space, especially in the beginning, is given to the explanation and analysis of theorems and exercises, in order to bring out clearly the plan of attack and the method of proof. Later, only statement and analysis, or statement alone, is made of theorems and exercises, and the pupil is expected to work out complete proofs in a carefully kept notebook.

There is a close connection with the first-year algebra, and the pupil learns to use algebraic facts and principles as effective tools in his geometric work. In connection with ratio and proportion the trigonometric functions are introduced. The exercises are in excess of the requirement for the work of one year and they contain numerous illustrations of the practical value of geometry. The use of this book as advised by the authors will develop an aptitude for getting at the real difficulties in any problem or situation and for careful, neat, and accurate written work.

H. E. C.

Modern Business Arithmetic, Brief Course, by Harry A. Finney, Lecturer in Accounting, Walton School of Commerce, Chicago, and Joseph C. Brown, Director of Training School for Teachers, University of Illinois. Pages v+298. 15x21 cm. 1916. Henry Holt & Company, New York.

Only those topics and types of problems which have application in common business practice are included in this course in the essentials of business arithmetic. Each topic is introduced by a discussion of the business activities relating to it, and the illustrations and model forms are designed to instruct the student in the best methods in actual use. Facility in computation is afforded by an abundance of oral and written drill, and accuracy is secured by insisting that results shall be checked at every point. The list of business and professional men who have aided the authors in preparing this book makes it certain that the statements of business customs and the problem material are well adapted to prepare students to meet the exacting demands of the business world.

H. E. C.

First Course in General Science, by Frederick D. Barber, Illinois State Normal University, Merton L. Fuller, Bradley Polytechnic Institute, John L. Pricer, Illinois State Normal University, and Howard W. Adams, Illinois State Normal University. Pages vii+607. 13x19.5 cm. Cloth. 1916. $1.25. Henry Holt & Company, New York City.

The writer believes that practically every large publishing house has issued a text on general science. It is not the purpose of this review to enter into any critical discussion of the subject matter of this particular book. It is almost enough to say, knowing the authors as the writer does, that it is one of the very best books on general science that have ever been published.

The biological as well as the physical side of the subject is treated with great fairness. There is more material in the text than can be well used in one year's work on the subject. This is, however, a good fault, as it gives the instructor a wide range of subjects. The book is written in a style which will at once command, not only the attention of the teacher, but that of the pupil as well. It is interesting from cover to cover. Many new and ingenious features are presented. The drawings and halftones have been selected for the purpose of illustrating points in the text, as well as for the purpose of attracting the pupil and holding his attention. There are 375 of these illustrations.

The work is divided into ten chapters. The matter discussed in the major paragraphs is stated at the beginning in bold-faced type. There is no end to the good things which might be said concerning this volume, and the advice of the writer to any school board about to adopt a text in general science, is to become thoroughly familiar with this book before making a final decision. C. H. S.

Essentials of Geography, by Albert P. Brigham, Colgate University, and Charles T. McFarlane, Teachers College, New York. First book, pages vi+266. 21x26 cm. Cloth. 1916. 72 cents. Second book, pages vi+426. 21x26 cm. Cloth. 1916. $1.24. American Book Company, Chicago.

Much enterprise has been shown by this publishing house in bringing from the press these two most remarkable books on geography by two well-known teachers of the subject. The books are profusely illustrated, the pictures being selected with much care and being of such a nature as to illustrate the descriptive material of the text. In the first volume there are 420 pictures and cuts. The maps are nearly all new, and embody all of the recent data gathered by the surveys of the United States government as well as others. The first book is well adapted for pupils in the upper grammar grades. There are valuable appendices in each book, giving populations and pronunciation of the more difficult names.

The second book contains 608 pictures and cuts, and not only does it treat of the geographical phase of the earth, but the physiographic side of it is well covered. The maps are splendidly executed, and all material is of an authentic character. The descriptions are made in such an interesting way that the pupil will surely be interested in the subject matter. There are scattered throughout the texts numerous questions bearing upon the subjects discussed in the books. The two volumes deserve extensive adoption, and doubtless the sale will be large.

C. H. S.

A Textbook of Physics, edited by A. Wilmer Duff. Fourth edition. Pages xiv+692. 14x21cm. Cloth. 1916. $2.75. P. Blakiston's Son & Company, Philadelphia.

This textbook of physics is a modern Ganot. The printing of the fourth edition shows that this work by Duff, Carman, Lewis, McClung,

and Mendenhall is what physics teachers, both secondary and collegiate, want, not only for the purpose of a textbook but for reference. One can rest assured that the statements made in this volume are authentic. Many changes have been made in this fourth edition. A new part on "Sound" has been added, and attention especially brought to bear upon the work of Sabin and Miller. Authorities for statements are given, and at the end of various chapters a bibliography of physics texts, together with a list of questions and problems suggested by the discussion in the chapter, is given. No physics teacher can afford to be without this most valuable work. C. H. S.

Industrial Arithmetic, by Nelson L. Roray, Department of Mathematics in the William L. Dickinson High School, Jersey City, N. J. Pages viii+144. 13x19 cm. 75 cents net. 1916. P. Blakiston's Son & Company, Philadelphia.

Although many varieties of shop mathematics and practical arithmetics have appeared in recent years, this book is different enough from its predecessors to warrant a careful examination by those who wish a good textbook in industrial arithmetic. If furnishes drill and review in the elementary processes with pure numbers, and there is a good supply of problems boys must handle in the school shops and may meet in practical life.

While there is no formal approach to algebra, the use of letters in representing general numbers is introduced in formulas and equations. The most useful geometrical formulas are used in practical applications, so that the boy may get some knowledge of geometry in the first year of high school. The problem material is well chosen from shop work that is readily understood by the average boy, and presented in admirable form. H. E. C.

Outline and Suggestive Methods and Devices on the Teaching of Elementary Arithmetic, by Franklin P. Hamm, Supervising Principal of Cramer Grammar School, Camden, N. J. Pages v+40. 13x18 cm. 1916. J. B. Lippincott Company, Philadelphia.

After keeping a record for eight years of the arithmetical topics that gave special difficulty, and of the mechanical errors that led to poor work in the upper grades, the author has prepared this pamphlet. Its purpose is to aid teachers in regard to the topics studied in arithmetic and to the use of the most prevalent methods and devices. Many of the topics and methods have a direct bearing on the work of the succeeding grades, though the work of the fifth and sixth grades only is included in the outline. The suggestions in the pamphlet will certainly prove helpful to teachers. H. E. C.

First-Year Mathematics, by George W. Evans, Head Master of the Charlestown High School, Boston, and John A. Marsh, Master in Mathematics at the English High School, Boston. Pages 353. 13x19 cm. 90 cents, 1916. Charles E. Merrill Company, N. Y.

The criticisms that have been directed against the teaching of algebra in the secondary schools are not in vain. Recent textbooks show that it is not algebra, but formalism in algebra, that should be dropped. The textbook under consideration is one of the best examples of real, useful mathematics for the first year of high school, which will develop the ability of pupils to think clearly and to put on paper in orderly fashion the solution of problems. It is delightfully free of the old-time drill in handling literal expressions, just for the sake of algebraic experience, and still gives ample skill in the algebraic work of the first year. To read it will create a desire to use it in the classroom. H. E. C.

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